BF
671
.C585x
vol.17
no.2

Comparative Psychology Monographs

151.3
C738
V.17
#2

THE LIBRARY
BRIGHAM YOUNG UNIVERSITY
PROVO, UTAH

BF
671
.C585x
v.17
#2

Volume 17, Number 2 APRIL, 1941 Serial Number 86

COMPARATIVE PSYCHOLOGY MONOGRAPHS

MANAGING EDITOR
Roy M. Dorcus, University of California at Los Angeles

ASSOCIATE EDITORS
John E. Anderson, University of Minnesota
Harvey A. Carr, The University of Chicago
Knight Dunlap, University of California at Los Angeles
Walter S. Hunter, Brown University
Alfred V. Kidder, Carnegie Institution of Washington
Samuel O. Mast, The Johns Hopkins University
Robert M. Yerkes, Yale University

Form Discrimination as a Learning Cue in Infants

BING-CHUNG LING
University of Michigan

PUBLISHED BY
THE WILLIAMS & WILKINS COMPANY
BALTIMORE, MARYLAND, U. S. A.

Copyright 1941, by The Williams & Wilkins Company

THE LIBRARY
BRIGHAM YOUNG UNIVERSITY
PROVO, UTAH

COMPARATIVE PSYCHOLOGY MONOGRAPHS

Comparative Psychology Monographs will publish the more extended studies of animal behavior and in addition studies in human psychology conducted from the comparative point of view. Where it is desirable several studies from one laboratory may be grouped together as one or more numbers of this series.

Contributors should follow the method used in the *Monographs* in the citation of references and in the listing of bibliography. It is desirable that titles include some characterization of the problem studied and some indication of the subjects employed.

Manuscripts may be sent to Roy M. Dorcus, the University of California at Los Angeles, Los Angeles, California, or to the appropriate member of the editorial board.

Correspondence concerning business matters should be sent to The Williams & Wilkins Company, Baltimore, Maryland, U. S. A.

The periodical will be issued irregularly. A volume will consist of approximately 400 pages. Each volume may contain an irregular number of issues.

Subscription price: $6.00 net, postpaid. Single copies will be supplied when available. Subscriptions are accepted for the volume and not by the year.

Subscription may be placed through your agent or sent direct to the publishers.

THE WILLIAMS & WILKINS COMPANY, Baltimore, Maryland, U. S. A.

Composed and Printed at the
WAVERLY PRESS, Inc.
for
THE WILLIAMS & WILKINS COMPANY
Baltimore, Maryland, U. S. A.

Made in United States of America

151.3
C738
v.17
#2

FORM DISCRIMINATION AS A LEARNING CUE IN INFANTS*[1]

BING-CHUNG LING

University of Michigan

INTRODUCTION

There have been a number of studies in form discrimination in lower animals and human adults, but relatively little work has been done in the same field with children, especially with infants. Experiments by Line (42), Gellermann (15, 16), Skeels (52), Munn and Stiening (43), and Volkelt and Loebenstein (60) represent the more significant of these latter studies.

In addition to these experiments on form discrimination *per se* in children may be briefly mentioned those on the genetic development of form as related to other sensory and spatial attributes; viz., spatial orientation, size, number, color, etc.

In regard to spatial orientation in very young children there is, on the whole, agreement, namely, to a child a form is much more independent of its absolute spatial position than it is to adults [Koffka (36, p. 293); Vernon (58, p. 186); Gellermann (15, 16); Bühler (4, pp. 156–157); Jersild (31, p. 236); Johnson

---

* A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the University of Michigan.

[1] The writer wishes to express her deep appreciation to the members of her doctoral committee: Professors Walter B. Pillsbury, John F. Shepard, Burton D. Thuma and Willard C. Olson for many valuable suggestions and criticisms. She is especially indebted to Professor Martha G. Colby, Chairman of the Committee, for inspiration, encouragement, direction and advice both at the time of active research and during the writing of the dissertation. She also wishes to thank Doctors Harley A. Haynes, Norman F. Miller, D. Murry Cowie and their colleagues of the University Hospital for the pediatric examination of the subjects and for laboratory space for the experiment; her assistants, especially Doctor Charles H. Crudden who constructed the one-way observation cubicle, for their valuable aid in the different phases of the research; and finally, St. Joseph's Mercy Hospital, and the parents of the subjects, without whose loyal coöperation the experiment would have been impossible.

(32, p. 256); etc.]. On the other hand, the comprehensive data of Hanfmann (27) with twenty-two slightly older subjects (four to seven years) show that the "absolute orientation already influences the children's perception of shape" (27, p. 328). Rice (46) found that orientation of plane figures as a factor in perception appears to rise rather *suddenly* between the ages of five and six years.

Apropos of size, Bühler (4) states that the capacity for appreciating sizes is developed to a high degree of perfection in the first three years. Jersild (31), however, holds that "a young child is likely to make errors by judging objects in terms of their size rather than their form" (31, p. 237). Koffka (36) and Stern (55) report that size plays a very insignificant rôle in the recognition of things during the first eight or nine months of life. Brunswick and Cruikshank (3) found a definite approach toward the establishment of size-contancy within the perceptual system of the human infant by the second half of the first year.

Concerning grouping Schroff (49) found that experience does not play a part in perceptual grouping as such, but only in the *concomitant* meaning of forms. Rush (48), on the other hand, found that "the grouping response is by no means so simple an effect of the external 'field forces' as has sometimes been supposed" (48, p. 94) and that experience has a genuine influence on it.

In connection with the functional relationship between the units of the same form pattern Romero (47) found that the three-year-old child is able to gain insight into the functional relationship between these units and, therefore, exhibits no emotional disturbances when a crucial change is introduced into this relationship.

Regarding "synthetic" or "masked" forms Crudden's (7) experiment shows that the primary school child is able to "abstract a known figure from a relatively unknown configuration" (7, p. 52). This finding is substantiated by comparable adult experiments by Djang (10), Whiteside (65), etc.

In this experiment the color factor was deliberately kept a constant, since the consensus of opinion, despite some interesting

THE LIBRARY
BRIGHAM YOUNG UNIVERSITY
PROVO, UTAH

conflict, is that hue variation, as a more primitive perceptual process, would "overwhelm" form discrimination, especially at the infant age level [Werner (61), Katz (34), Déscoeudres (9), Segers (50), Bühler (4), Von Kuenburg (40), Tobie (56), Volkelt (59), Brian and Goodenough (2), Hetzer, Beaumont, and Wiehemeyer (28), Vernon (58), Rabello (44), etc.]. These conclusions are, however, of obviously critical significance to this study in that they so emphatically imply form perception as a "higher" and ontogenetically later process than color, mass as such.

Some reference should be made here to experimental work on tactual perception of form, since (1) it is widely regarded as a more primitive and probably contributing type, (2) it is obviously a natural factor in the spatial behavior of children. Volkelt (60), Révész (45), and Katz (33) have shown that the same forms may be about equally well discriminated tactually and visually by both adults and children. Révész stresses that the two phenomena are completely parallel in development, showing the same tendencies and obeying the same laws.

Aside from these experimental findings on the various sensory and spatial attributes as related to the genetic development of form perception there are a number of general statements and space perception theories from leading psychologists which are related to or dependent upon the concept of primitive form perception [Koffka (36), Shinn (51), Arlitt (1), Curti (8), Vernon (58), Stern (55), Werner (61, 62), Bühler (4), Lewin (41), Volkelt (60), Wheeler and Perkins (64), etc.].

Thus Koffka writes:

> It is not the simplest of geometrical forms, but those biologically the most important, which are first evident in infantile perception. From her twenty-fifth day forward, Miss Shinn's niece took an interest in human faces, which in her second quarter-year she was able to distinguish as familiar and unfamiliar. To teach the child "simple figures" is possible only at a much later time [twelfth month], (36, p. 289).

Vernon writes:

> We have referred from time to time to the fact, first emphasized by the Gestalt psychologists, that the perceptions of young children may

differ considerably from those of adults, and may resemble more closely those of animals, especially of the primates. Particularly are children likely to perceive the field as a series of undifferentiated meaningful wholes. Thus in some ways the configurational tendencies operate more strongly in them than in adults; children tend to ignore detail, and their perceptions are vague, fluid, inaccurate, and liable to modification in accordance with subjective tendencies (58, p. 178).

Stern divides the development of space perception into three successive stages:

(1) The development of "own space" perception. Here the individual body as a whole—the head at least—is the starting place.

(2) The development of "near space" perception. The principal organic contributors to this development are mouth, hand and eye, especially hand. The senses of smell and hearing take a secondary place in this development.

(3) The development of "distant space" perception. The "distant space" perception starts to develop after the first three months when convergence and accommodation for a distance of several meters begin. It is only really mastered when it is connected or translated into "near space," and this is done by the child's own power of motion (55, pp. 114–24).

Werner (61) repeatedly emphasizes the contrast between mature and primitive space perception. The perception of the young child, the primitive man, and lower animals all show the qualities of diffuseness, vagueness, lack of specific inter- and intra-relationship, wholeness or "homogeneity," from which specific relationships are only slowly abstracted.

Werner (62) essentially agrees with Stern in his theory of space perception. His developmental periods are:

(1) Primitive physiognomic and physiological stage.

(2) Higher level of function, i.e., *perceptual* interpretation of size, form, distance, color, which develops slowly, with its peak at 15 years.

(3) "Conceptual" stage.

Finally, the fundamental importance of the ontogenetic approach to the basic problems of space perception is illustrated by Gottschaldt's (22) statement, that the problem of primitive space perception is the nucleus problem of all psychological development (22, p. 147). Again he states that few experiments are so important as those which try to determine the visual space development of the child.

In view of these statements and the experimental findings mentioned earlier, there seem to exist at least three conflicting views with regard to genetic facts and theories of the factor of form discrimination in visual space perception.

(1) Are the finer capacities in form discrimination, i.e., specific geometric *detail* as opposed to "mass" differences, present at very early age levels? Or are they, as so frequently labelled, an "advanced" form of mental activity which emerges "relatively late" from a more primitive, "diffuse" state? What is the bearing of such data on the nativistic and empirical concepts of space perception?

(2) How minute may these objective differences (sensory cues) be? Or conversely how easily may they be obscured by a "primitive" level of perception, "vague, fluid, inaccurate and liable to modification in accordance with *subjective* tendencies" (58, p. 178)? What is the genetic evidence for the "Law of Prägnanz" as stated by Wertheimer (63), Koffka (36), Werner (61), etc.?

(3) Is the nature of the infant's discrimination of geometric form (1) sufficiently inexperienced, or (2) sufficiently "vague, diffuse and homogeneous" to be easily affected by changes in such collateral "topological," "geographical" space attributes as orientation, position, size, number, sequence, etc.?

To summarize the problem in a more general form:

(1) Is genetic form discrimination a primitive, innate, immediate and relatively "absolute" process determined primarily by differences of cue in the sensory image (stressing sensory maturation and topological organization)?

(2) Is it a "derived" and therefore delayed process dependent primarily on the maturation of a "g" factor or some analogous capacity of perceiving the *functional* relationships of contours (stressing central processes)?

(3) Has it in earlier stages essentially the qualitative and quantitative genetic differences so widely ascribed to it in psychological theories of space perception?

The present investigation is an attempt to contribute toward a solution of these conflicting views by systematic and intensive experimentation at early human age levels. It is fourfold in its purpose:

(1) To determine the nature and extent of geometric form discrimination in infants with special reference to the collateral factors of sequence, position, orientation, number, size, synthesis ("masking") and functional relationship.

(2) To study the efficacy of such discrimination as a cue in the various phases of the learning process, with special reference to simple habit formation, retention and recall, inhibition, individual differences, transfer, etc., in a relatively simple situation such as has been set up in the genetic psychology laboratory of the University of Michigan.

(3) To analyze *quantitatively*, for the first time, all those *dynamic* concomitants of a specific response which are so urgently stressed by contemporary theories of "integrative" or "whole" behavior [Gottschaldt (22), Werner (61), Koffka (36), etc.].

(4) To trace, by continuous *longitudinal* experimentation, as opposed to the sampling method, the finer phases of chronological maturation as related to the foregoing processes.

THE EXPERIMENT[2]

The experiment, which constituted the main portion of the research, was preceded by seven months of intensive and controlled exploratory work, using fourteen subjects, aged six to twelve months. These data are not included here.

A. SERIES I–V INCLUSIVE

I. Apparatus

The apparatus consisted of:

a An experimental cubicle walled with one-way vision screens (see Fig. 1).

---

[2] See thesis or microfilm copy for complete experimental data.

b. A regular hospital crib, on one end of the railing of which was placed a gray oblong board, 89 cm. by 50.7 cm. by 2 cm. in dimension. Twenty-seven and a half centimeters from the left and right sides of the board, and 31.5–35.5 cm. from the farther, and 12.5–16.5 cm. from the nearer edge in the longitudinal direction were drilled five small circular holes, 1.6 cm. in diameter and 6.9 cm. from one another. (The position of the five circular holes in relation to the experimental board is described with reference to the position of the subject.) These holes formed a semicircle with the concave side facing the subject. They were equidistant from the infant as well as from one another. During the experiment any of these holes not covered by the form blocks were stopped with thin cardboard disks painted with the same gray paint used for the experimental board so that they were rendered invisible. Directly beneath these holes were five metal devices by means of which the stimulus blocks could be

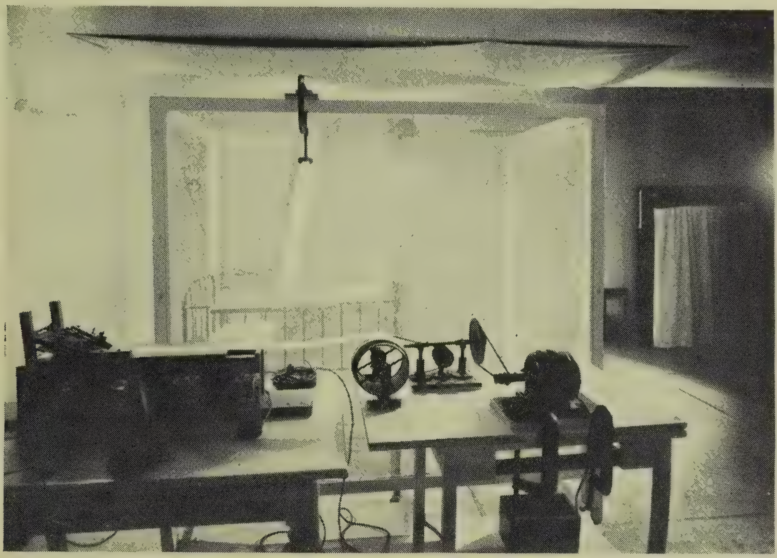


Fig. 1. Form Discrimination Apparatus

In the foreground is the time recording apparatus. Directly behind it is the one-way vision cubicle, inside of which are the experimental crib, the experimental board, and two form blocks.

fastened to the board at will. The subject was seated immediately in front of the board with the blocks within easy natural reach and grasp. Between the infant and the stimulus blocks was a one-way vision wire screen which was suspended from the top rails of the experimental cubicle. By means of an articulated lever this screen could be swung back and forth and adjusted at will, thus covering or uncovering the stimuli according to the nature of the experimental trial (see Fig. 1).

c. A series of geometric form blocks, standard size and large size, consisting of circles, ovals, squares, triangles and crosses. Within each of the two specified sizes these blocks were of equivalent area or radius. All of them were given several coats of bright yellow enamel paint with a glossy finish. The forms represented definite increases in "difference" of optical image, i.e., degree and number of "angle" cues. The blocks were kept continuously sterilized by means of 0.1 per cent $HgCl_2$. As a means of reinforcing the manipulative motivation by additional gustatory motivation, the blocks were immersed in a strong saccharine solution and dried before each experimental sitting (see Table 1).

TABLE 1

Dimensions of form blocks used in the experiment

FORM BLOCKS	STANDARD SIZE	LARGE SIZE
Circle	$1\frac{7}{16}$ inches, diameter	2 inches, diameter
Oval	$2\frac{7}{16}$ by $1\frac{5}{16}$ inches	$3\frac{1}{4}$ by $1\frac{3}{4}$ inches
Square	$1\frac{1}{2}$ inches, side	2 inches, side
Triangle	$1\frac{11}{16}$ inches, side	$2\frac{5}{16}$ inches, side
Cross	$\frac{1}{2}$ inch, length or width of arm $1\frac{1}{2}$ inches, total length or width	$\frac{5}{8}$ inch, length or width of arm $1\frac{7}{8}$ inches, total length or width

All blocks one-half inch thick.

d. A time recording apparatus, consisting principally of two electrically operated pens. One of these pens was attached to an electric metronome which beat every half-second. The other was connected with a key by means of which the various data could be accurately recorded. A stop watch was simultaneously used to double check all time records (see Fig. 1).

II. Method of Procedure

a. Preliminary Procedure

Prior to admission to the genetic psychology laboratory, the subject was given a very thorough pediatric examination and a Gesell (17, 18, 19) test. The latter was repeated every month during the experiment. Specific socio-economic and general hereditary background were as carefully ascertained as possible, through home visits and case history records.

b. Experimental Procedure

This part of the experiment consisted of five series. In Series I ("Forward Learning") the subject was seated in the experimental crib in front of the experimental board described above. After an adequate period of general adaptation, usually unexpectedly brief, a signal was given by the experimenter, whereupon the assistant started the time recording apparatus and swung back the screen at the same time, thus exposing to the subject two bright yellow blocks, a circle and a cross (or an oval). At the time of the presentation both blocks were in position on the experimental board over the second and fourth of the five above-described round holes. The circle (positive stimulus) was not fastened to the board, while the cross, or the oval (negative stimulus) was; therefore the subject was unable to pick up the latter, whereas the former would yield to his grasp and would taste sweet if put into his mouth. Careful qualitative and quantitative records were kept concerning visual regard, selection (i.e., the block reached for), reaction time, handedness and the affective attitude (including vocalization) accompanying the reaction. As soon as the subject succeeded in picking up or at least definitely dislodging the positive stimulus (circle), the screen was swung forward to its original position and the trial was considered completed. During the succeeding trials the relative position of the blocks was varied in a prearranged random order so that the subject might not get a cue from the positional factor to aid him in the discrimination. Care was also taken to see that there was no difference in time between the trials in which the series called for a change in the position of the stimuli and the trials in which the stimuli remained in the same position. Eight correct choices out of ten successive trials were arbitrarily set up as the standard for the perfect discrimination performance.

Due to the very young age levels of the subjects, no attempt was made to limit the number of trials carried out during each sitting. The infant was allowed to continue in his experiment as long as his interest held. Each child was brought to the laboratory three times a week at regular intervals.

When the subject had succeeded in meeting the standard for perfect discrimination, the cross, or the oval (negative stimulus) was replaced by a triangle, or a square, and the experiment repeated. This was continued until the subject had learned to choose the circle as against the cross, triangle, square and oval. This completed the Series I Experiment.

The same general procedure for Series I was used in the next three series of experiments. Each contained, however, a specific modification, designed to test a specific phase of the general problem. In Series II ("Change in Spatial Orientation of Negative Stimuli") all the negative blocks were turned a certain number of degrees to the right prior to the presentation (cross and square, 45°; oval, 90°; and triangle, 180°). This was to determine whether or not the subject used absolute spatial orientation as a cue. In Series III ("Change in Relative Size") the relative size of both the positive and negative stimuli was varied in order to see if size might play a critical part in the form discrimination of a human infant. In Series IV ("Increase in Number") the number of blocks presented simultaneously was increased from two to three, to four, and finally to five. In this last series, for the three-block situation, the standard for perfect discrimination performance was seven correct choices out of ten successive trials; for the four-block situation, six out of ten; and for the five-block situation, five out of ten. This was done to offset partially a disproportionate increase in the difficulty of the discrimination brought about by the arithmetical increase in the number of the blocks simultaneously presented. This fourth series was to determine whether or not increase in the number of stimuli (i.e., complexity of the total visual pattern, or "field organization") rendered the task of discrimination more difficult for the child; or, in terms of Gestalt theory, whether this new pattern, altered in "Komplexqualitäten and Ganzqualitäten" and, therefore, in "Gestaltqualitäten," will significantly alter the discrimination reaction and, therefore, the learning of the infant. In all these last three series a brief review of what the subject had learned in Series I preceded the experiment proper.[3] This was done not only to check the permanency of the subject's habits, as established in Series I, but also to make certain that in case of failure, it was not due to the fact that he had forgotten his original learning, but rather that he had been relying heavily on some particular spatial cue or combination of cues.

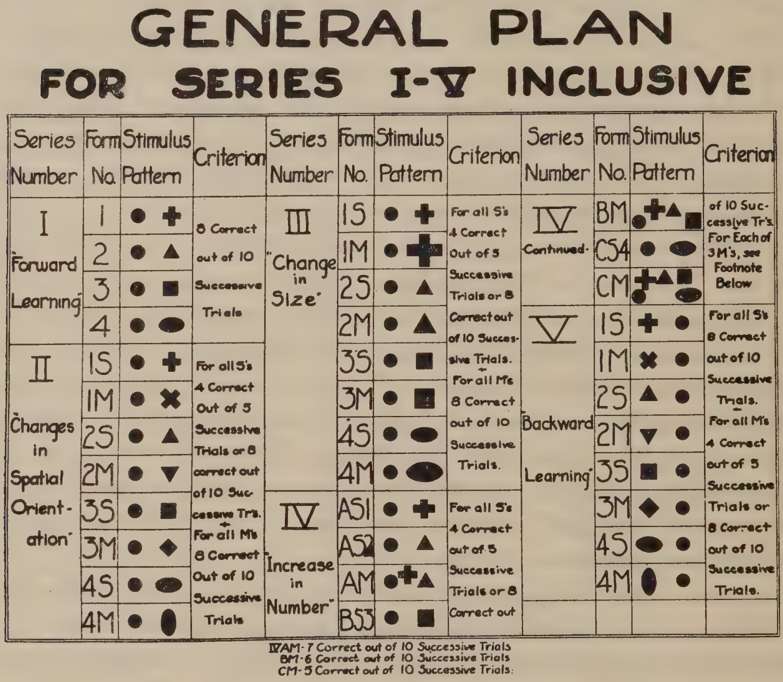
In Series V ("Learning in Reversed Order") the procedure was the same as in the previous series except in one respect, i.e., the preceding experimental condition was reversed so that now the circle became the negative stimulus and each of the other forms a positive stimulus. This was done (1) to study the qualitative and quantitative aspects of readjustment, inhibition, etc. as conceived by the Conditioned Reflex School; and (2) to find evidence for or against "abstraction" at this age level in the sense of "insight" into the transfer of functional *relationship* between two geometric forms.

As soon as the subject had learned a given form combination in Series V, the positive stimulus (cross, triangle, square, or oval) was turned a certain number of degrees to the right (cross and square, 45°; oval, 90°; and triangle, 180°). This section of the experiment, known as Series V Modified, was designed to determine whether or not change in the spatial orientation of the *positive* form (cf. Series II on page 10) would affect the discrimination performance of the subject. Opinion of this factor is about equally divided, between those who believe that young children excel adults in perceiving form *per se* as an "absolute," and those who assert that because of the "diffuse wholeness" of early spatial experience even a slight change in orientation will confuse or inhibit correct discrimination.

---

[3] In all the review experiments (known as Series II Standard, Series III Standard, and Series IV Standard) the criterion for perfect discrimination performance was either four correct choices out of five successive trials—if the subject fulfilled the requirement during the first five trials—or eight out of ten. This alternative was introduced to shorten the review sections of the experiment.

This section of the experiment had, as criterion for success, either four correct choices out of five successive trials—if the subject fulfilled the requirement during the first five trials—or eight out of ten. This alternative was introduced to prevent the unnecessary prolongation of Series V for those subjects who gave convincing proof of being unaffected by the change in the spatial orientation of the positive stimulus (see Fig. 2).



GENERAL PLAN
FOR SERIES I-V INCLUSIVE

Series Number	Form No.	Stimulus Pattern	Criterion	Series Number	Form No.	Stimulus Pattern	Criterion	Series Number	Form No.	Stimulus Pattern	Criterion
I "Forward Learning"	1	● ✚	8 Correct out of 10 Successive Trials	III "Change in Size"	1S	● ✚	For all S's 4 Correct Out of 5 Successive Trials or 8 Correct out of 10 Successive Trials. For all M's 8 Correct out of 10 Successive Trials.	IV Continued	BM	● ✚ ▲ ■	of 10 Successive Tr's. For Each of 3 M's, see Footnote Below
	2	● ▲			1M	● ✚			CS4	● ⬬	
	3	● ■			2S	● ▲			CM	✚ ▲ ■ ● ⬬	
	4	● ⬬			2M	● ▲		V "Backward Learning"	1S	✚ ●	For all S's 8 Correct out of 10 Successive Trials. For all M's 4 Correct out of 5 Successive Trials or 8 Correct out of 10 Successive Trials.
II "Changes in Spatial Orientation"	1S	● ✚	For all S's 4 Correct Out of 5 Successive Trials or 8 correct out of 10 Successive Trs. For all M's 8 Correct Out of 10 Successive Trials		3S	● ■			1M	✖ ●	
	1M	● ✖			3M	● ■			2S	▲ ●	
	2S	● ▲			4S	● ⬬			2M	▼ ●	
	2M	● ▼			4M	● ⬬			3S	■ ●	
	3S	● ■		IV "Increase in Number"	AS1	● ✚	For all S's 4 Correct out of 5 Successive Trials or 8 Correct out		3M	◆ ●	
	3M	● ◆			AS2	● ▲			4S	⬬ ●	
	4S	● ⬬			AM	● ✚ ▲			4M	⬮ ●	
	4M	● ⬮			BS3	● ■					

IV AM-7 Correct out of 10 Successive Trials
BM-6 Correct out of 10 Successive Trials
CM-5 Correct out of 10 Successive Trials:

FIG. 2

III. *Subjects*

Over fifty infants, ranging in age from six to twelve months, selected at random from high, medium and low socio-economic status, and including both the white and negro races, participated in the study, which lasted fourteen months. Of these, twenty-six infants gave quantitatively complete (i.e., longitudinal) data. With the exception of Case F, who was, as shown by a sequence of Gesell (17, 18, 19) tests, definitely immature both posturally and manipulatively, all the subjects were normal or supernormal children both in their mental and physical development. Case F was continued in order to suggest such specific behavior deviations as might later be used in setting up a similar experiment for immature and retarded infants.

For the purpose of comparing the relative difficulty of the four different stimulus patterns in each series from the standpoint of form discrimination, the twenty-six subjects were evenly divided into two subgroups. Subgroup I learned to discriminate forms in an ascending order of difficulty; i.e., from the most dissimilar in geometric contour, as circle versus cross, to the most similar, as circle versus oval. Subgroup II learned in a descending, or opposite, order of difficulty.

Ten infants in Subgroup I and eight in Subgroup II completed the entire study. These are referred to as the Regular Experimental Cases. The rest of the twenty-six subjects—three in Subgroup I and five in Subgroup II—learned only certain portions of the experiment. They are called the Irregular Experimental Cases.

IV. Results

Altogether 14,652 trials were carried out with the twenty-six Regular and Irregular Experimental Cases. These data were analyzed, both qualitatively and quantitatively, first on the basis of achievement, then on the basis of development. The former analysis was further divided into six subheadings: (1) Number of Trials, (2) Percentage of Success, (3) Reaction Time, (4) Oral Behavior, (5) Vocalization, and (6) Affective Concomitant. The latter analysis consisted of: (1) Number of Form Combinations, (2) Number of Trials, (3) Percentage of Success, (4) Reaction Time, (5) Oral Behavior, (6) Vocalization, (7) Affective Concomitant, (8) Visual Regard, and (9) Manipulation.

a. Analysis on the Basis of Achievement

1. Number of Trials

Data analyzed in terms of the total number of trials required by each subject in both subgroups of the Regular Experimental Group in the learning of (1) Series I–V inclusive, (2) each series, and (3) each form show the very marked individual differences among the members of the same subgroup in their ability to meet the requirements of the experiment, as against the relatively small differences in the same ability between Subgroups I and II as a whole. Their ability is measured by the differences in size between the (1) averages, (2) medians, and (3) mean deviations of the respective groups (see Fig. 3).

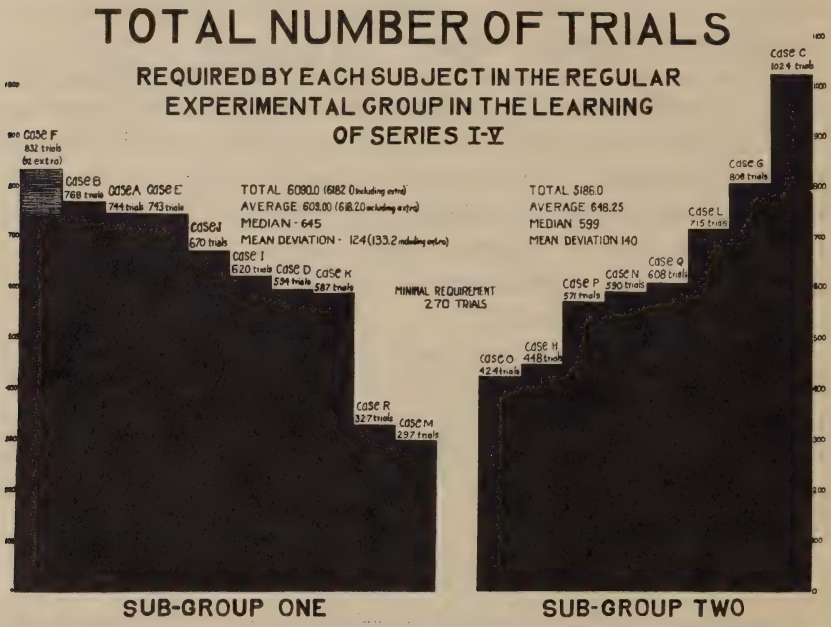


FIG. 3

Results on the average number of trails required by Subgroups I and II respectively of the Combined Regular and Irregular Experimental Groups in the learning of each of the five experimental series (see Fig. 4) show that:

a) Subgroup II learned Series I in appreciably fewer trials than Subgroup I (124.10 trials for Subgroup II and 147.08 trials for Subgroup I). However, careful examination of the scores obtained by each individual subject in the two groups in the learning of each form constituting Series I revealed the fact that the total number of trials required by Cases F and J respectively of Subgroup I in the learning of Form 1 are unusually large and deviate very significantly from the norm for the group. Since no such deviations appear in the scores of the two subjects for any other form, it seems highly probable that the abnormally high scores in this case are due to some other reasons, such as unusually slow initial adjustment to the general experimental situation, than that directly connected with the form discrimination and the learning ability of the subjects. Consequently it seems justified, in comparing various types of results of the two subgroups, to exclude the scores of Cases F and J from the means of Subgroup I. When this was done in the present case, the scores for the two subgroups were not far apart. The difference was only 1.08 trials fewer with Subgroup I.

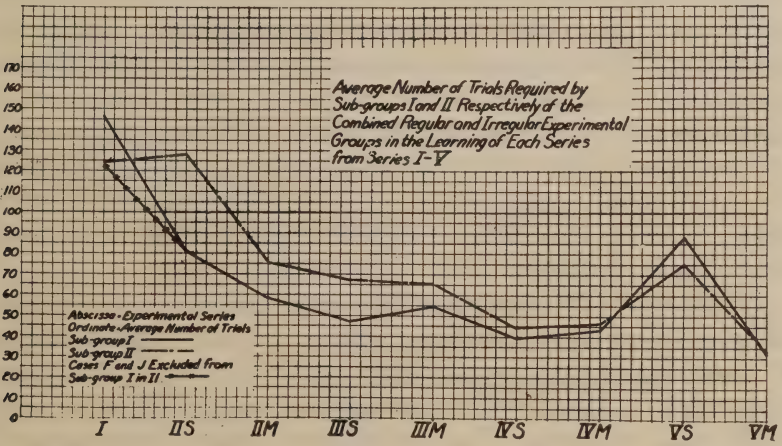


FIG. 4

b) In Series IIS, IIIS, and IVS (the three review experiments in which Series I was relearned) Subgroup I showed consistent superiority over Subgroup II. It is also interesting to note here that the difference between the two subgroups in the number of trials required to learn a given series decreases consistently in size as one goes from Series IIS to IIIS and then to IVS. (The differences are 46.02 trials for Series IIS, 20.27 trials for Series IIIS, and 4.70 trials for Series IVS.)

c) In Series IIM, IIIM, and IVM ("Change in Spatial Orientation of Negative Stimuli," "Change in Relative Size," and "Increase in Number") Subgroup I again showed superiority over Subgroup II. Furthermore, the difference between the two subgroups again diminishes consistently (from 18.0 to 3.8 trials) as one goes from IIM to IIIM and then to IVM. This implies that in spite of the exactly opposite order of presenting the geometric combinations, some common *general* factor in the experience begins to operate very early and very permanently. At the same time, however, these reduced group differences remain internally consistent enough to indicate that the specific factor, *order of presentation* (sequence), does affect the scores in discrimination performance.

d) Series VS ("Learning in Reversed Order") is a very conspicuous example of this latter effect. In this series Subgroup II showed a decided superiority over Subgroup I (difference, 12.47 trials). However, this difference is reduced to a minimum (0.23 trials) in Series VM ("Change in Spatial Orientation of Positive Stimuli"), implying at once that of the two factors in discrimination, change of functional relationship, as such, seems much more critical than change of orientation, as such.

e) Turning now from dissimilarities to similarities between the parallel data for the two groups, it is significant that the initial scores are conspicuously high for both Subgroups I and II (147.08 and 124.10 trials respectively). This is obviously the result of general adjustment to the whole experimental situation. From there on, the scores fall steadily in spite of the various types of specific changes and all the possibilities of confusion introduced in Series IIM and IIIM. In Series IVM ("Increase in Number") the scores remain low; however, as there were here only three form combinations as against four in IIM and IIIM, the situations in these three series were not strictly comparable. Had there been also four form combinations in Series IVM, the scores would undoubtedly have risen to some extent at this point. Then the proportionate lowering of the standard of success for this series (see page 10) in an attempt to offset partially a disproportionate increase in the difficulty of the discrimination brought about by the arithmetical increase in the number of blocks simultaneously presented may have contributed also.

At VS both scores rise abruptly and significantly (from 39.80 to 88.10 trials for Subgroup I and 44.50 to 75.63 trials for subgroup II). This seems plainly due to the very drastic change in the experimental task at this point (exchanged *functional relationship* between positive and negative figures). The scores drop to a new low at VM (32.90 trials for Subgroup I and 33.13 trials for Subgroup II), showing that the subjects were undisturbed by the change in the spatial orientation of the *positive* stimulus in this last series.

Results on the total and average number of trials required by Subgroups I and II respectively of the Combined Regular and Irregular Experimental Groups in the learning of each form in Series I–V (see Table 2[4]) and also results on the average number of trials for each form group required by Subgroups I and II respectively of the Combined Regular and Irregular Experimental Groups in the learning of Series I–V (see Table 3) show that:

a) Both groups of subjects spent the largest number of trials in learning the first form combinations presented to them (Sub-

---

[4] Case F learned Series I, Form 1 *technically* in 228 trials, i.e., met the standard for perfect discrimination performance on the 228th trial. However, his total behavioral pattern during the last ten trials was such that the experimenter was in doubt as to the reliability of the score; therefore five more trials were given as a check, and the percentage of success obtained during these trials was sixty, twenty below the criterion for successful learning. As a consequence, the same experiment was continued until the subject had carried out altogether 320 trials on Series I, Form 1, before he gave convincing proof of having mastered the form. In the quantitative analysis of the results, in order to render the scores from Case F in the form in question technically comparable to those from other cases, they were presented both with and without the inclusion of the ninety-two extra trials (320 − 228 = 92). This was done in this table as well as in the other tables in which Case F's data on Series I, Form 1 were included.

TABLE 2

Total and average number of trials required by Subgroups I and II respectively of the combined regular and irregular experimental groups in the learning of each form in Series I–V

EXPER. NO.	STIMULUS PATTERN	SUBGROUPS I		SUBGROUPS II	
		Total	Average	Total	Average
I1	Circle-Cross	785 (877) 442*	60.38+ (67.46+) 40.18+*	222	22.20
I2	Circle-Triangle	358	29.83+	235	21.36+
I3	Circle-Square	223	18.58+	395	32.92−
I4	Circle-Oval	413	34.42−	583	44.85−
II1s	Circle-Cross	319	26.58+	156	17.33+
II1m	Circle-Cross	175	14.58+	102	11.33+
II2s	Circle-Triangle	161	13.42−	219	24.33+
II2m	Circle-Triangle	165	13.75	143	15.89−
II3s	Circle-Square	121	11.00	298	33.11+
II3m	Circle-Square	138	12.55−	196	21.78−
II4s	Circle-Oval	312	28.36+	480	53.33+
II4m	Circle-Oval	162	16.20	247	27.44+
III1s	Circle-Cross	152	15.20	144	16.00
III1m	Circle-Cross	145	14.50	126	14.00
III2s	Circle-Triangle	80	8.00	89	9.89−
III2m	Circle-Triangle	124	12.40	140	15.56−
III3s	Circle-Square	107	10.70	134	14.89−
III3m	Circle-Square	144	14.40	152	16.89−
III4s	Circle-Oval	135	13.50	242	26.89−
III4m	Circle-Oval	137	13.70	176	19.56−
IVas1	Circle-Cross	144	14.40	116	14.50
IVas2	Circle-Triangle	93	9.30	89	11.13−
IVam	Three-Block Situation	178	17.80	107	13.38−
IVbs3	Circle-Square	62	6.20	74	9.25
IVbm	Four-Block Situation	104	10.40	158	19.75
IVcs4	Circle-Oval	99	9.90	77	9.63−
IVcm	Five-Block Situation	154	15.40	114	14.25
V1s	Cross-Circle	322	32.20	102	12.75
V1m	Cross-Circle	88	8.80	57	7.13−
V2s	Triangle-Circle	162	16.20	93	11.63−
V2m	Triangle-Circle	87	8.70	76	9.50
V3s	Square-Circle	249	24.90	111	13.88−
V3m	Square-Circle	86	8.60	58	7.25
V4s	Oval-Circle	148	14.80	299	37.38−
V4m	Oval-Circle	68	6.80	74	9.25

The figures within the parentheses are obtained by including 92 doubtful trials of Case F.

* These figures are obtained by excluding the results of Cases F and J in Series I, Form 1.

group I, circle-cross combination; Subgroup II, circle-oval combination). Then for Subgroup II the number of trials required for the learning of each of the other three form combinations became increasingly smaller in the direct order in which these combinations were exposed. The same was true for Subgroup I until it came to the circle-oval combination. The number of trials here immedicately rose from 73.43 to 116.08 (see Table 3). At least two explanations are possible for this discrepancy. The first is as follows: Subgroup II was presented, at the outset, with the two forms (circle and oval) which were the most geometrically similar of those used in the present study; therefore the subjects were forced to notice rather fine differences from the start (training of finer attention processes). As the experiment progressed, this initial training carried over marked "trace" effects, and thus, fewer and fewer trials were necessary to discriminate between each successive combination of forms. Subgroup I, on the other hand, started out with a circle and a cross which were very different in geometrical contour. This was indeed a much more gross geometric difference than that

TABLE 3

Average number of trials for each form group required by Subgroups I and II respectively of the combined regular and irregular experimental groups in the learning of Series I–V

SUBJECTS	CIRCLE-CROSS GROUP	CIRCLE-TRIANGLE GROUP	CIRCLE-SQUARE GROUP	CIRCLE-OVAL GROUP
	I1, II1s, II1m, III1s, III1m, IVas1	I2, II2s, II2m, III2s, III2m, IVas2	I3, II3s, II3m, III3s, III3m, IVbs3	I4, II4s, II4m, III4s, III4m, IVcs4
Subgroup I	145.64 125.44* 152.72† (1)	86.70 (3)	73.43 (4)	116.08 (2)
Subgroup II	95.36 (4)	98.16 (3)	128.84 (2)	181.70 (1)

The figures within the parentheses indicate the rank order (descending) of the figures directly above.

* These figures are obtained by excluding the results of Case F and Case J in I1.

† These figures are obtained by including the 92 doubtful trials of Case F.

between a circle and an oval; therefore the subjects were not forced to notice fine differences until they came to the circle-oval combination. There they were confronted with an apparently more difficult situation than that for which their previous combinations had prepared them, so the requisite number of trials went up considerably at this specific point, making Series I, Form 4 uniquely though not insurmountably difficult for the subjects of Subgroup I. If the above interpretation is correct, then we might infer that the circle-oval combination is perceptually or "behaviorally" [Koffka (37)] more difficult to discriminate than the other form combinations, an opinion which will be later reënforced by analysis of the results on reaction time. When it comes to each of the other form combinations, the available data do not seem to indicate any such clear-cut difference in relative difficulty.

A second possible explanation is as follows: Subgroup II, deprived of using sharp *angle* cues in its first learning, did not primarily rely on these in the subsequent form combinations where they appeared. The behavior of Subgroup I, on the other hand, implies that the sudden disappearance of these angular cues as such in the last form combination to be learned was a profoundly disturbing factor. [Hanfmann (27) stresses the use of a "symbolic" angle as the critical cue in geometric form perception, and states that this occurs only with younger children.]

b) Variations in the relative size of the forms did not affect detrimentally the discrimination performance of either group of subjects; nor did the pronounced orientation change in the optical image (e. g., □→◇) of a major unit in the total pattern affect this total organization to the detriment of internal discrimination (see Table 2). From these data it seems very clear that neither spatial orientation of a unit as such nor size as such is the *primary* cue in any of the many learning series of this experiment, as reflected in the achievement scores. In other words, it seems that even at these very early age levels, there is a "form-constancy" which is of a very elementary perceptual nature. However, as will be seen later, such *qualitative* aspects of achievement as reaction time, etc., show clearly *some influence* from changes in the spatial orientation or size of a major unit in the total stimulus pattern.

c) Increase in the number of blocks presented simultaneously caused an increase in the total number of trials required for the learning of these "synthetic" patterns [Krasnogorski (39)]. However, the amount of increase was not directly proportional to the increase in the number of blocks (see Table 2). Furthermore, it was appreciable but not marked, thus indicating that increased complexity of pattern by numerical addition rendered the task of form discrimination more difficult, but not impossible, for the subjects of either group [cf. Gottschaldt (22)]. In other words, the infants' discrimination, while somewhat affected, was never completely *masked* by *any* combination or "synthesis" of units in these given patterns. This implies that neither (1) configuration complexity in terms of multiple separate units, nor (2) possible "geographical" synthesis [Wertheimer (63)], nor (3) synthesis through "trace" or familiar factors [Hanawalt (26)] of certain forms within the total pattern appears completely to mask the discrimination of form *per se* as evidenced in achievement scores. On the other hand, regardless of interpretation, a multiple geometric pattern (viz., five units) is much more difficult than a simple geometric pattern (viz., two units) at this age level.

d) The results of the Series V, Form 1, Standard experiment show that the subjects of both groups were at first profoundly disturbed when the positive stimulus was abruptly made negative and one of the negative stimuli positive for the first time (see Table 2). The total number of trials required for learning this reversed functional relationship increased from an average of 14.40 to 32.20 for Subgroup I and from 9.63– to 37.38– for Subgroup II. However these marked disturbances lasted a surprisingly brief period and affected *only* the scores for the first form combination of Series V (Subgroup I, cross-circle combination; Subgroup II, oval-circle combination). After a period of marked confusion, both perceptual and emotional, both groups soon detected the change in relationship and were able at once to readjust themselves successfully to the new situation. This is shown by the abrupt return to normal size of the numbers of trials required for the learning of all other form combinations in Series V. Qualitatively, the results of Series V seem to show (1) a degree of plasticity in readjustment (reconditioning) unexpected at this "primitive" age level [Krasnogorski (39)], (2) a primitive form of "insight" [Köhler (38), Koffka (36)], and (3) evidence of "abstracting" a relationship to the extent of inhibiting future use of a thoroughly established motor habit.

2. Percentage of Success

> Percentage of success is obtained by dividing the number of correct trials by the total number of trials.

Data on the percentage of success obtained by each subject in both subgroups of the Regular Experimental Group in the learning of Series I–V inclusive show that:

a) The difference between the grand percentage of success for Subgroup I (64.24 – %) and that for Subgroup II (64.83 – %) is very insignificant (0.59%).

b) The individual differences among the members of the same subgroup in the learning of Series I–V are appreciable but not marked.

When the same data were analyzed in terms of the percentage of success obtained by each subject in the learning of (1) each *series* and (2) each *form*, the individual differences became much more marked.

When the individual scores in percentage of success obtained in the learning of Series I–V were correlated with those in total number of trials obtained in the learning of the same five series, a negative coefficient of 0.89 ± .033 was obtained. It is interesting to note, in this connection, that cases with very high or very low percentages of success have, as a rule, very small or very large total numbers of trials, respectively; the two types of scores bear a very significant negative relationship for the same individual. Cases whose percentage of success scores fall somewhere in the median range generally have medium scores in total number of trials, but those scores do not bear such a clear-cut negative correlation.

Quantitative results on the average percentages of success obtained by Subgroups I and II respectively of the Combined Regular and Irregular Experimental Groups in the learning of each series from Series I–V show that Subgroup I exceeded Subgroup II in Series IIS (5.26%), IIM (7.98% and IIIM (5.68%), while Subgroup II showed superiority over Subgroup I in Series IVM (2.99%), VS (1.84%) and VM (4.33%). In series IIIS and IVS the two groups were practically equal. In series I when the score for Subgroup I was left uncorrected by including the data from Cases F and J on Form 1, Subgroup II obtained a higher percentage of success than Subgroup I; but after the same data were excluded, the two groups were only 0.33 apart in their respective percentages of success for Series I.

Turning now from differences to similarities between the two sets of parallel scores in percentage of success for the two subgroups, it is significant that their general distribution in size confirms the points brought forth on pages 16–17 with one exception: the very *abrupt* drop at IVM as against the very slight rise for the total number of trials. This marked fall in the former case is obviously attributable to the interplay of two divergent factors discussed earlier: increase in the difficulty of the task (numerical complexity of the stimulus pattern) and a proportionate lowering of the standard for perfect discrimination (see page 10).

Data on the average percentages of success obtained by Subgroups I and II respectively of the Combined Regular and Irregular Experimental Groups in the learning of each form in Series I–V and also data on the average percentages of success for each form group obtained by Subgroups I and II respectively of the Combined Regular and Irregular Experimental Groups in the learning of Series I–V confirm, on the whole, the results shown in Tables 2 and 3 (see pages 18 and 19).

3. Reaction Time

Average reaction time per trial is obtained by dividing total reaction time by total number of trials.

Data on the total reaction time required by each subject in both subgroups of the Regular Experimental Group in the learning of (1) Series I–V inclusive, (2) each series, and (3) each form within each of the series show:

a) Marked individual differences among the members of the same subgroup in the total amount of reaction time required to learn Series I–V.

b) A decided difference between the two subgroups in the total reaction time as shown by (1) averages, (2) medians, and (3) mean deviations of the respective groups (see Fig. 5).

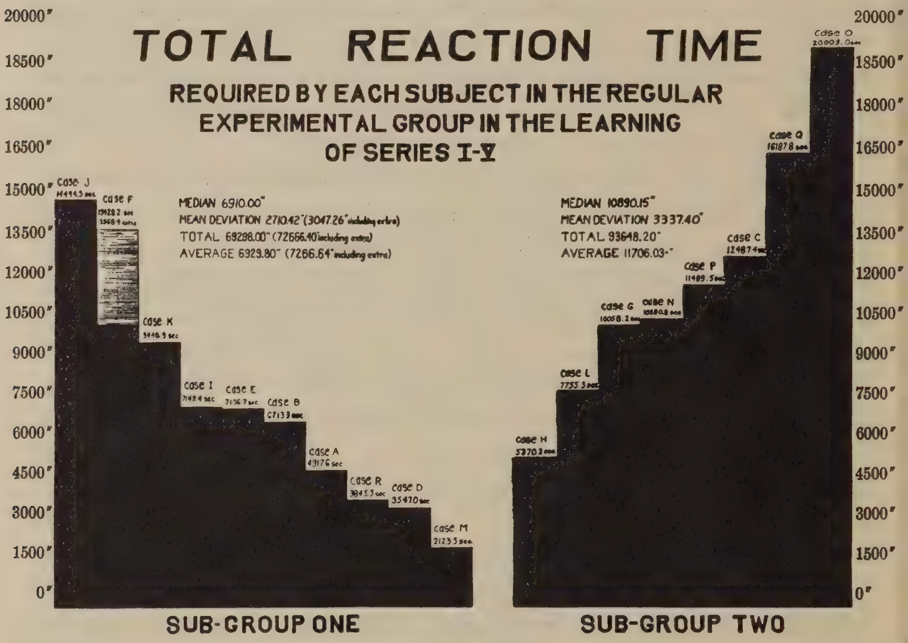


FIG. 5

When the individual scores in total reaction time were correlated with those in total number of trials, a positive coefficient of only 0.25 ± .15 was obtained. This was to be expected, because even though there were a number of subjects who were both fast and efficient learners, or both slow and inefficient learners, there were also many others who were either slow but thorough, or fast but superficial, in their learning.

Results on the *average reaction time for each series* required by Subgroups I and II respectively of the Combined Regular and

Irregular Experimental Groups in the learning of Series I–V (see Fig. 6) show that:

a) Subgroup II spent decidedly much more time than Subgroup I in learning its initial series. This is true before and after the score for the latter group was corrected by excluding the data from Cases F and J on Series I, Form 1. However, after the initial series, this difference between the two groups decreased steadily through IIS, IIM, IIIS, IIIM and IVS. It increased abruptly at IVM. At VS, the two groups exchanged places in the relative size of their scores, and for the first and only time during the entire Series I–V, Subgroup II spent less time than Subgroup I in the learning of an experimental series. At VM the two groups again exchanged places, and Subgroup I spent less time than Subgroup II in learning the series. However, this last difference was relatively insignificant (374.98 sec. v.s. 405.63 sec.).

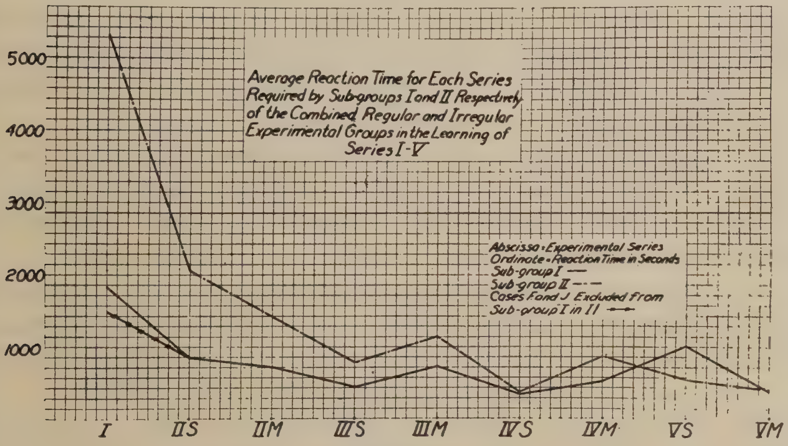


Fig. 6

b) Turning now from dissimilarities to similarities between the two sets of parallel scores for the two subgroups, it is significant that they both start very high, i.e., with a very large total reaction time. This is obviously another indication of a *general* initial adjustment to the total experimental situation. The scores fall steadily through IIS, IIM and IIIS, in spite of all changes in pattern, viz., the spatial orientation of the negative blocks at IIM. Both sets of scores rise slightly and similarly at IIIM, fall at IVS, rise again in different magnitudes at IVM (see pages 16–17; the same statistical considerations hold here), and VS, and fall significantly at VM. The different rises at IIIM, IVM and VS are probably due to different degrees of effectiveness of change in relative size, of increase in the number of units, and of interchange of functional relationship (cf. pages 16–17).

Data on the *average reaction time per trial* required by Subgroups I and II respectively of the Combined Regular and Irregular Experimental Groups in the learning of each series from Series I–V show essentially the same general characteristics as described above under a) and b) on pages 25–26 with two exceptions:

a) There is a slight rise in parallel scores for both subgroups at IIM, showing that both groups of subjects were somewhat, though very little, disturbed by change in the spatial orientation of the negative stimuli.

b) The score for Subgroup II decreases rather than increases at VS. The only possible inference for this unexpected result is somehow the initial training of Subgroup II on the basis of very fine form differences (cf. pages 19–20).

Data on the total and average reaction time required by Subgroups I and II respectively of the Combined Regular and Irregular Experimental Groups in the learning of each form in Series I–V and also data on the average reaction time for each form group required by Subgroups I and II respectively of the Combined Regular and Irregular Experimental Groups in the learning of Series I–V confirm the four points (see pages 17 and 19–22) shown in Tables 2 and 3 (see pages 18 and 19) with one notable exception: change in the relative size of the stimuli did, on the whole, raise the scores (from 2.31 to 147.55 sec.) in the average reaction time required by both subgroups in the learning of each form combination in Series III. One possible explanation for this would be that even though such a change did not affect detrimentally the discrimination performance of either group of subjects, it increased the manipulative difficulty of the positive stimulus for the smaller infants (A number of cases were recorded in which the subjects experienced much difficulty in grasping and securing the large circle.), thereby increasing the reaction time for the learning of a given form combination.

4. Oral Behavior

> By oral behavior is meant all the activities, exclusive of vocalization, of the mouth with reference to the stimulus blocks. The significance of oral behavior is widely emphasized by genetic psychologists on the basis of three general hypotheses:
>
> 1. Stern (55), Révész (45) and others include it as a genetically elementary form of tactual *manipulation* in which the sensitive tactual reactions of the lips and mouth at first combine with, and are only very gradually superseded by, those of the hands and fingers. This universally long period of "mouthing" objects in infancy is thus interpreted as a form of tactual *space* experience rather than purely gustatory or a "sensitive zone" satisfaction (in the Freudian sense).
> 2. Oral activity is also widely regarded as a diagnostic overflow phase of behavior of two types: (a) chronic nervousness of a general constitutional type, (b) nervousness normally produced by and in proportion to the difficulties within a problem task, especially where fine discrimination may tax perceptual equipment.
> 3. It is also widely regarded as being universal evidence of the mass-activity pattern of normal behavior characteristic of early infancy [Irwin (29)].

Data on the percentage of trials in which oral behavior was exhibited by each subject in Subgroups I and II of the Regular Experimental Group in the learning of Series I–V show that:

a) Individual differences among the members of the same subgroup in the amount of oral behavior exhibited during the learning of Series I–V are very marked.

b) Group differences, while present, are relatively small. This is shown by the small differences in the (1) means, and (2) medians of the two subgroups.

c) About 71 per cent of the subjects of the Regular Experimental Group exhibited both "regular" oral behavior (By "regular" oral behavior is meant that form of oral behavior in which the stimulus block is actually in contact with the subject's mouth.) and "special" oral behavior. (By "special" oral behavior is meant that form of concomitant oral behavior in which the stimulus block is not in actual contact with the subject's mouth.) Close observation of the total behavior pattern of this 71 per cent throughout the entire experimental period suggests that this latter type of oral behavior occurred particularly in those infants who were more variable, labile, plastic and versatile in their activities than their companions who exhibited little or no "special" oral behavior. However, the amount of "special" oral behavior present in a given subject was not correlated, either positively or negatively, with the degree of success in his discrimination performance. The amount of "regular" oral behavior, however, bore an appreciably high positive correlation with the degree of success in his discrimination task. While the exact coefficient of correlation has not been finally computed, it may be estimated as somewhat above 0.60. This seems offhand to confirm the interpretation of "mouthing" [Stern (55), Volkelt (60), Révész (45)] as a tactual experience of some importance in the development of spatial qualities (see page 35). In any event, it seems to illustrate the results of enhancing motivation through a gustatory reward.

When the individual scores in oral behavior ("regular" + "special") were correlated with those in total number of trials, a negative coefficient of 0.64 ± .094 was obtained. One might attribute this rather high degree of correlation between the two apparently distantly related phenomena in question to the combined result of two important factors discussed above: (1) the maintenance or even enhancement of *initial motivating factors* toward the positive stimulus through additional gustatory reward, (2) the addition of a second tactual aid in perceptual discrimination of contour.

Data on the average percentages of trials in which oral behavior was exhibited by Subgroups I and II respectively of the Combined Regular and Irregular Experimental Groups in the learning of each series from Series I–V show the distribution of oral behavior in this part of the experiment. One possible interpretation of these scores, based on the assumed use of oral activity as a tactual auxiliary cue in infants' form discrimination, and the ability of these infants as measured by their scores in the total number of trials, percentage of success and reaction time, is as follows:

The relatively high initial incidence of oral behavior in Subgroup II is apparently again related to the greater difficulty of the initial task; therefore the total behavior pattern was more complex, as evidenced in oral behavior, reaction time, etc. The subjects in Subgroup I, on the other hand, began with a less difficult task and their initial responses were therefore qualitatively less complex or "diffuse" with less incidental mouthing as a motor "irradiation," and consequently less likelihood of forming a mouthing habit.

From Series I on to Series IVM both groups of subjects apparently found their tasks to be of medium difficulty. Here the complexity of the total behavior pattern, including oral activity, diminished.

In Series VS Subgroup I apparently found the change in the functional relationship between the positive and negative stimuli very upsetting, and in this series there is a striking increase in the incidence of oral behavior. Subgroup II, on the other hand, was not so greatly disturbed by the change, and its oral behavior increment was not so marked.

In Series VM, where both groups proved easily adjustable to the change in the spatial orientation of the positive blocks, the incidence of oral behavior markedly decreases.

Data on the average numbers and percentages of trials in which oral behavior was exhibited by Subgroups I and II respectively of the Combined Regular and Irregular Experimental Groups in the learning of each *form* in Series I–V corroborate the statements just made (see pages 28–29). Thus, whatever be the significance or interpretation of this form of behavior, it is a dynamic concomitant clearly related in infancy to the difficulty of a given task.

5. *Vocalization*

> As with the general type of oral activity discussed earlier, vocalization is likewise widely regarded by genetic psychologists as an important diagnostic clue to behavior processes. For example, Gesell (17, 18, 19) and Bühler (4) include it as an item in their developmental tests. Fajans (11, 12) makes it one of her main criteria in analyzing *distance* as a spatial "vector" in infant reactions to a specific goal. Gellermann (15, 16) goes still further in regarding it as a specific *aid* in form discrimination. All observers agree that it is at least an important clue to the emotional character of the situation.

Data on the percentage of trials in which vocalization occurred with each subject in the two subgroups of the Regular Experimental Group in the learning of Series I–V show that:

a) Individual differences among the members of the same subgroup during the learning of Series I–V are marked.

b) Group differences are relatively insignificant.

c) Among the three types of vocalization expressions of pleasantness greatly predominate except in Cases K and R. Expressions of unpleasantness are second in order of frequency in 56 per cent of the cases, third in 33 per cent of the cases, and first in Cases K and R. Communicative vocalization (Communicative vocalization is that type which clearly conveys some spatially directed meaning; such as, an attempt to communicate with someone or something, the sounds accompanying a search for the block after it has slipped out of the subject's grasp or has disappeared from sight, etc.) is the least frequent in eleven, and second in seven of the total eighteen subjects.

When the individual scores in vocalization were correlated with those in total number of trials, a positive coefficient of correlation of $0.0058 \pm .16$ was obtained. This complete lack of correlation between the two types of behavior under consideration would seem to invalidate the very common use of vocalization increment as a reliable behavior criterion indicative of the ease or difficulty of a given perceptual pattern or learning task [cf. Fajans (11, 12)]. However, that vocalization is intimately related to the general "dynamic" or affective phases of behavior remains unchallenged.

The complete experimental data on vocalization show that incidence and type of vocalization seems more indicative of the amount of interest and the state of adjustment to the different aspects of the general experimental situation than of the degree of learning success or the amount of difficulty in any specific discrimination "Aufgabe" beyond parts of the experiment such as Series I and IIM and Form V1s.

6. *Affective Concomitant.*

> The term "affective concomitant" seems self-explanatory both in meaning and importance. For convenience, data are quantitatively classified in five orders of decreasing pleasantness.

Data on the percentages of trials in which different aspects of affective concomitant were observed in the subjects of the two subgroups of the Regular Experimental Group in the learning of Series I–V show that:

a) *Pleasantness* is by far the most predominant (mean, 89.56 – %). *Neutral concomitant* is second in order of frequency (mean, 10.79 + %). *Unpleasantness* comes third with a mean of 10.10 – %. *Very pleasant concomitant* is fourth with a mean of 9.65 – %, while *very unpleasant concomitant* is the least frequent of all (mean, 1.02 – %).

b) From the point of view of individual differences, *pleasantness* again heads the list with a range of 97.43 + % to 70.03 + %. The others, listed in order of diminishing range, are *unpleasantness* (27.94 – % to 0.67 + %), neutral concomitant (24.03 + % to 2.34 + %), *very pleasant concomitant* (20.72 + % to 2.16 + %), and *very unpleasant concomitant* (3.47 + % to 0%).

c) From the standpoint of group differences, it is significant that *pleasantness* is the most frequent, and that *very unpleasant concomitant* is the least frequent for both of the subgroups. *Unpleasantness* comes second in order of decreasing frequency for Subgroup I and fourth for Subgroup II. *Neutral concomitant* is third for Subgroup I and second for Subgroup II, while *very pleasant concomitant* is fourth for Subgroup I and third for Subgroup II.

The complete experimental data on affective concomitant show, among other things, one important point; namely, the relative proportion of the five aspects of affective concomitant in a given subject seems more indicative of the amount of that individual's interest in and the state of his adjustment to the different aspects of the general experimental situation than of the degree of his learning success or the amount of his difficulty in any specific discrimination "Aufgabe" beyond parts of the experiment such as Series I and IIM and Form V1s. This is indeed the very generalization reached in the case of vocalization. Such, however, is to be expected since vocalization is one of the primary indices of the affective state of the subject.

In conclusion it may be said that both affective concomitant and vocalization, although so widely used [viz., Gottschaldt (22), Fajans (11, 12), etc.], are really somewhat unreliable objective criteria for the apparent difficulty of a given task and the subject's success in it.

b. Analysis on the Basis of Development[5]

1. Total Number of Form Combinations

In spite of obvious individual differences in the total number of form combinations learned per experimental period during any given age level, there are certain general trends common to the subjects of the Regular and Irregular Experimental Groups. These trends are as follows:

a) A general tendency in all groups for the number of form combinations learned per experimental period to increase steadily from the seventh to the eleventh or twelfth month. After this there was a definite plateau or even decrease. The improvement was probably due to the combined effect of maturation and learning, and the decline, to the loss of interest in the task which had now become too simple or too stereotyped.

b) From the seventh to the eleventh month Subgroup I surpassed Subgroup II in form combinations learned per experimental period, except for one insignificant exception at the eighth month level. At the eleventh month level, performance is reversed, Subgroup II now excelling Subgroup I. This, again, seems clearly related to order of presentation, i.e., relative difficulty of discrimination task.

---

[5] This part of the analysis covers seven age levels—from the seventh to the thirteenth month of life. All the subjects in both the Regular and Irregular Experimental Groups completed the entire Series I-V experiment during or before the thirteenth month except Case A of Subgroup I who completed the experiment at the fifteenth month. Since she was the only one who did this, the analysis does not go beyond the thirteenth month.

2. Total Number of Trials

The same tendencies—(1) marked individual differences, within (2) a steady group increase in trials per experimental period from the seventh to the eleventh or twelfth month, followed by a definite plateau or even decrease from then on—are found here, and probably have the same causes. The reversed relationship between Subgroups I and II, however, is not duplicated here.

3. Percentage of Success

a) Individual differences are again present; however, they are not so marked as in (1) total number of form combinations, or (2) total number of trials.

b) There is again a general tendency in both subgroups for the scores to increase from the seventh month on. However, this increase is slight and irregular.

c) There is no consistent or stable difference between the two subgroups in percentage of success through these age levels, but rather an irregular alternation with small statistical range (2 to 9 per cent variation).

4. Reaction Time

a) GROUP DIFFERENCES. At each age level from the seventh to the thirteenth month, in both total reaction time per experimental period and average reaction time per trial, Subgroup I differed significantly from Subgroup II in two ways:

1) The scores for Subgroup I show a short reaction time at first, an increase to the tenth month, and a fall to its minimum at the thirteenth month.

One possible interpretation of these scores is that during the first days of the experiment the subjects of Subgroup I were too young to maintain their interest in the task very long. As they grew older, they were able generally to prolong both their experimental period and their reaction time per trial, thus learning to discriminate with increasing accuracy more and more forms (see 1. a) on page 32). After the tenth month they had reached a stage in development in which they were able both to perceive and to perform so fast that there was no longer any need for them to spend much time on the "Aufgabe" during any one trial or to remain in the experimental crib for any great length of time. Furthermore, as the range of attention expanded, they became increasingly impatient with the task which had apparently become too simple or too confined.

The scores for Subgroup II, on the other hand, show a long initial reaction time, a descent to the minimum at the tenth and eleventh months, and some minor rises at the twelfth and thirteenth months. This is practically the opposite of Subgroup I's reaction time.

Since the two subgroups were carefully equated in both chronological and developmental ages, the longer reaction time for Subgroup II during the first months could not be interpreted as an indication of a higher degree of maturity on the part of the group; therefore initial sequence of difficulty of the task seems once more the only explanation.

2) With the exception of the tenth month, reaction time for Subgroup II was consistently higher than that for Subgroup I. Aside from a possible difference in personality between the groups, the cause, again, seems to be the different order of pattern presentation.

b) INDIVIDUAL DIFFERENCES. Both in total reaction time per experimental period and in average reaction time per trial individual differences among the members of the same group are very marked.

5. Oral Behavior

a) INDIVIDUAL DIFFERENCES. Individual differences in oral behavior are very marked among the members of the same subgroup and are apparently quite unrelated to age.

b) Group Trends. *1*) *Distribution of Oral Behavior.* The initial incidence of oral behavior for both subgroups is relatively high. This is probably due to the interplay of two important factors: (1) a characteristically high incidence at the seventh month maturation level, and (2) power of the gustatory motivation factor. As stated earlier, most authorities regard oral behavior as a form of manipulation characteristic of this age level (see page 27).

The steady descent of both sets of parallel scores after the ninth month is probably explainable by the combined effect of: (1) a natural waning of oral activity due both to maturation and to social inhibition; (2) the gradual dominance of complex manual activity over primitive gustatory lures as motivating factors; and (3) increasingly rapid eye-hand domination of behavior [cf. Stern (55), Gesell (17, 18, 19), Bühler (4), etc.].

The contrast between the two sets of parallel scores for Subgroups I and II respectively is probably attributable to the different order of pattern presentation as discussed above. In other words, oral behavior is apparently a qualitative concomitant of behavior related to a *specific task* as well as to maturation.

2) *Frequency of Oral Behavior.* In every month except the thirteenth, Subgroup II exhibited oral behavior more frequently than Subgroup I. This difference was more marked during the seventh, eighth and ninth months than in the following three months. Of the total number of trials in which oral behavior was present, between 98 to 99 per cent of them contained "regular" oral behavior; about 1 to 2 per cent, "special" oral behavior; and about ½ per cent, both kinds. This last statement applies to both subgroups.

Since the use of oral behavior apparently did aid discrimination performance (see page 28), and also in view of the initial difficulty in task for Subgroup II, it seems possible to infer that Subgroup II, either through involuntary "motor irradiation" or deliberately, made greater use of oral activity as an auxiliary learning cue than did Subgroup I. Common maturational and social factors in both groups, however, seem indicated in the common decline of oral behavior after the ninth month.

6. *Vocalization*

a) Individual Differences. Individual differences in vocalization, both regarding the total amount present and the relative proportion of the three different types (see page 30), with relation to age are marked.

b) Group Trends. *1*) *Distribution of Vocalization.* Data on the percentage of trials in which vocalization occurred in Subgroups I and II respectively of the Combined Regular and Irregular Experimental Groups at each age level in the learning of Series I–V show:

(a) A process of gradual and permanent adjustment to the experimental situation in general and the stimulus patterns in particular can be traced through these seven successive age levels (from the seventh to the thirteenth month).

(b) There are no consistent group differences except at the very beginning and after the eleventh month.

(c) Neither the total amount of vocalization, nor the distribution of the three types (i.e., pleasant, unpleasant, and communicative) correlate with the degree of success obtained by either subgroup throughout the seven consecutive age levels, as measured by the form combination, trial and reaction time scores.

2) *Amount of Vocalization.* On the whole, Subgroup II was more voluble and more variable in type than Subgroup I.

7. *Affective Concomitant*

a) Individual Differences. Individual differences are present in all the five aspects of affective concomitant (i.e., very pleasant, pleasant, neutral, unpleasant, and very unpleasant), but in different degrees. These differences tend to persist through all maturational levels.

b) Group Trends. In general, none of the five aspects of affective concomitant seem to correlate with achievement in either group, throughout the seven consecutive age levels, as measured by the form combination, trial and reaction time scores, or with specific maturation level. Pleasantness is by far the most predominant affective concomitant at all the seven consecutive age levels covered by this part of the study. The extreme aspects of pleasantness and unpleasantness are very infrequent.

8. *Visual Regard*

When the six months infants were first presented with the stimulus blocks, they usually looked at them at once. However, this visual regard was, as a rule, momentary and intermittent; and was directed to one block at a time, very often completely ignoring the presence of the other until it was discovered that the first stimulus (if it happened to be the negative form) was fixed to the board. As they grew older, attention increased both in span and duration. By the ninth and tenth months, visual regard was much more sustained and coördinated. Attention was rarely limited to one block. On the contrary, they surveyed the entire visual field at one glance; or if the stimulus pattern was unusually complex, such as the five-block situation in Series IV, Section C, Modified, they examined each block singly and systematically by turning their heads slowly from one end of the visual field to the other in a semicircular fashion, fixation apparently determined by spatial sequence (proximity) more than by geometric contour. After having secured the positive block, instead of immediately putting it into their mouths as younger infants did, they usually examined it very closely with varied manipulation.

By the twelfth and thirteenth months attention had increased so greatly both in range and duration, and a relative motor maturity had made them so active, that they refused to sit still in the crib and the once highly motivated individual task had now only a temporary interest. Frequently, therefore, their visual regard was rarely confined to the stimulus pattern, but shifted rapidly from object to object within the experimental cubicle. However, during these moments of "coöperation" they showed coördinated, controlled, alert and sustained visual regard, of the type not to be found in infants of earlier age levels.

9. Manipulation

In general, the manual behavior patterns in this experimental situation follow the developmental sequence established by Castner (5), Halverson (23, 24, 25), True (57), etc., namely, (1) failure to contact, (2) contact only, (3) primitive squeeze, (4) squeeze grasp, (5) hand grasp, (6) palm grasp, (7) superior palm grasp, (8) inferior forefinger grasp, (9) forefinger grasp, (10) superior finger grasp and (11) double grasp.[6]

Analysis of handedness data in this study on the basis of development shows that all the infants could be classified, according to their hand preference, into three distinct types: (1) those who were predominantly right-handed (44.44+%), (2) those who were predominantly left-handed (22.22+%), and (3) those who shifted from the predominant use of one hand to that of the other from month to month in a rhythmical sequence (33.33+%). This last type is particularly interesting from the genetic point of view, and its presence has been substantiated by Giesecke (21) in his study of the genesis of hand preference.

In spite of these differences in type, however, it was the predominant tendency of all the subjects at all the seven age levels covered by the present study, to secure the stimulus block with the hand which was on the same side as the block. This strong motor-positional factor showed no decline with growth within the age limit used in this study.

Data on handedness further show that unimanual activities predominated throughout all the age levels studied (7–13 months). This is not in agreement with the Yale finding that although unimanual activities predominate in the first year of life, there is a period (32–36 weeks) during which the infant is strongly bimanual (20). The absence of such a bimanual period in the infants of the present study may be due to the experimental procedure which required that all trials in which the infants contacted both blocks simultaneously with both hands be discarded.

Finally, the same data show that handedness in a given infant did not bear any consistent or significant relationship with his ability as a learner or his interest in the "Aufgabe." Neither did it show any correlation with the difficulty of the task. On the other hand, the data conclusively prove that three consistent ontogenetic differences in handedness occur at these early age levels.

---

[6] For description of these different types of grasping reactions, see True, A. *Prehension in the colored infant*, (Doctor's thesis), pp. 59–63.

B. SERIES VI

I. Introduction

This part of the investigation was designed to study the following questions:

a. Do "trace" or transfer effects occur in a situation in which the familiar geometric forms are now conceivably "masked" through various combinations of figures, i.e.,

1. Will young infants show any evidence of discrimination selection based on experience within these hypothetically fused contours, or

2. Will the composite figure prove a new perceptual experience, i.e., perceived as a total homogeneous unit?

b. If "trace" effects do occur, how are these related to various mechanical laws of learning, i.e., primacy, recency, frequency, sequence, etc. of the various preceding series?

c. If perceived as a new configuration, how, if at all, do such external factors as "goodness" of external or internal contours, or both, simplicity (homogeneity), complexity (number and arrangement of angles), combination of circularity and angularity, position, etc. appear to influence the subjects' reactions? Genetically regarded, these factors would certainly seem related to such general theoretical concepts as "Prägnanz," "Law of Least Action," etc., as involved in perceptual responses.

II. Apparatus

The experimental set-up was the same as in the previous series except in form blocks used (see pages 6–8). These blocks were so constructed that each single form was now superimposed upon another single form, thus introducing a second figure-ground relationship optically and the above-mentioned behavior possibilities functionally (see page 39). Since the blocks were of uniform color, the principal visual cues to the superimposed contour were restricted to optic depth (perspective factors). To the adult eye these contours at this standard distance are sharp and clear so that the familiar geometric forms are neither "geographically" nor "behaviorally" fused. [The experimental distance is well within the "body-radius" of the infant. Compare Stern (55), Bühler (4), Fajans (11, 12), etc.] There is very little known, however, about the visual perception of figural depth *per se* in infancy.

Three series of form blocks were required for this part of the study. They are:

a. Double-circles, double-ovals, double-squares, double-triangles and double-crosses. Each of these forms was composed of two large-sized blocks used in Series III superimposed one on top of the other.

b. Circle-on-crosses, circle-on-triangles, circle-on-squares and circle-on-ovals. Each of these forms was composed of a standard-sized circle placed on top of a large-sized cross, triangle, square or oval.

c. Cross-on-circles, triangle-on-circles, square-on-circles and oval-on-circles. Each of these forms was composed of a standard-sized cross, triangle, square or oval placed on top of a large-sized circle.

III. Method of Procedure

This varied in three ways from the previous series.

a. The problem here is not one of learning, but of spontaneous preference or selection.

b. Neither of the paired compound forms was fastened to the board.

c. The scheme of presentation was altered as follows:

Section A	Circle-Cross Combinations	
Part 1	Double-Circle	Cross-on-Circle[7]
Part 2	Double-Cross	Circle-on-Cross
Part 3	Circle-on-Cross	Cross-on-Circle

---

[7] Each part consisted of four trials. In the first and fourth trials the first block (e.g., Double-Circle) was placed to the right of the subject and the second block (e.g., Cross-on-Circle) to the left. In the second and third trials the relative positions of the two stimuli were reversed.

Section A	Circle-Cross Combinations	
Part 4	Double-Circle	Circle-on-Cross
Part 5	Double-Cross	Cross-on-Circle
Part 6	Double-Cross	Double-Circle

Section B	Circle-Triangle Combinations	
Part 1	Double-Circle	Triangle-on-Circle
Part 2	Double-Triangle	Circle-on-Triangle
Part 3	Circle-on-Triangle	Triangle-on-Circle
Part 4	Double-Circle	Circle-on-Triangle
Part 5	Double-Triangle	Triangle-on-Circle
Part 6	Double-Triangle	Double-Circle

Section C	Circle-Square Combinations	
Part 1	Double-Circle	Square-on-Circle
Part 2	Double-Square	Circle-on-Square
Part 3	Circle-on-Square	Square-on-Circle
Part 4	Double-Circle	Circle-on-Square
Part 5	Double-Square	Square-on-Circle
Part 6	Double-Square	Double-Circle

Section D	Circle-Oval Combinations	
Part 1	Double-Circle	Oval-on-Circle
Part 2	Double-Oval	Circle-on-Oval
Part 3	Circle-on-Oval	Oval-on-Circle
Part 4	Double-Circle	Circle-on-Oval
Part 5	Double-Oval	Oval-on-Circle
Part 6	Double-Oval	Double-Circle

IV. Subjects

The subjects, ranging in age from 35 weeks 4 days to 59 weeks 1 day, included (1) twelve subjects of the Regular Experimental Group who had had intensive training through Series I–V, and (2) an equal number of subjects of the Control Group carefully matched in age and developmental scores. Both groups were further divided into two subgroups. Subgroups I performed in the forward order, i.e., from Section A to D; Subgroups II performed in the backward order, viz., from Section D to A.

V. Results

Altogether 2304 trials were carried out by the twenty-four subjects. These data were analyzed, both qualitatively and quantitatively, under form preference, reaction time, manipulation and the various dynamic attributes previously discussed.

a. Form Preference

Data on the number and percentage of times in which each member of the total twenty-four pairs of stimuli was secured either in preference to or simultaneously with the other member of the pair by Subgroups I, Subgroups II and Combined Subgroups respectively of the Experimental and Control Groups are very scattered and therefore provide few clues as to how the infants actually perceived these compound patterns. For this reason further analyses of these results on the basis of three different assumptions, all representing comparative (adult) approaches, have been attempted.

The first analysis is based on the assumption that in a given compound block the top form is visually more potent than the bottom form, because the former (1) retains in full its continuity in shape, and (2) is higher in relief from the general background, whereas the latter (1) is partially covered by the former, thereby losing much of its homogeneity, and (2) is lower in relief. Consequently, taking Section A as an example, the order of potency from the circle to the cross would be (1) double-circle, (2) circle-on-cross, (3) cross-on-circle, and (4) double-cross.

The second analysis is based on the assumption that in a given compound block the bottom form is more potent than the top form, because the former, by virtue of being slightly larger, serves as a sort of framework for the latter and consequently may partially absorb the latter by weakening its contour. Likewise, it retains the strong advantage of a color difference against the gray background. Accordingly, taking Section A as an example, the order of potency from the circle to the cross would be (1) double-circle, (2) cross-on-circle, (3) circle-on-cross, and (4) double-cross.

The third analysis is based on the assumption that if the top form in a given compound block is a cross, triangle, square, or oval, and the bottom one a circle, the resultant block will assume the shape of the former, because a non-circle is a more complex contour than a circle and, therefore, possibly as a matter of attention or "intent," will effectively resist absorption by the simpler figure. If, on the other hand, the two constituent forms reverse their relative positions so that now the circle is on top, this, in turn, will be partially absorbed by its more complex background or framework. As a result a new Gestalt—neither of the components as such but a combination of them—will be originated. Taking the circle-on-cross and cross-on-circle combination (Section A, Part 3) as an example, the cross-on-circle remains cross-like in appearance while the circle-on-cross, owing to the partial absorption of the circle by the cross, assumes a totally new shape which is intermediate between the two component forms.

As a result of the three above analyses based on three very different hypotheses of figure-ground relationship, it was found that the trained subjects behaved astonishingly like the untrained subjects in their spontaneous selection of patterns. Whether such seemingly "traceless" reactions were due to inhibition of memory effects by new Gestalten, or whether they were the result of the neutralization of previously reversed positive and negative effects, or whether they represented the "understanding" of and therefore immediately successful adjustment to a new situation ("insight") on the part of the trained subjects, cannot be determined by this manner of analysis. Equally obscure, therefore, is the problem of how these compound blocks were visually perceived by either group.

Another significant point derived from the above analyses is the apparently spontaneous though marginal preference, exhibited by the trained and untrained subjects alike, for non-circle forms. This seems on the surface, at least, inconsistent with the prevailing concept that "primitive" minds will respond most directly to the simplest, i.e., most homogeneous, configurations in cases of free choice as the easiest course of actions.

b. Reaction Time

Although the subjects of the Experimental Group behaved astonishingly like those of the Control Group in their spontaneous selections of geometric patterns, they were consistently and markedly faster than the latter infants in both total reaction time and average reaction time per trial. This was quite obviously a case of transfer or "trace" of previous training.

c. Manipulation

On the whole, the Control Cases, somewhat more frequently than the Experimental Cases, employed bimanual approach to the stimulus patterns. Since all preceding series required that the subjects use unimanual approach only, this may be regarded as evidence of the positive transfer of learning. The Experimental Group, on the other hand, tended to resort to positional cue in their manipulative reactions to the blocks slightly more persistently than the Control Group. This difference is explainable by the fact that the more frequent use of bimanual approach by the untrained subjects reduced the number of times in which the positional cue might be used by those subjects. However, the fact that the Experimental Cases did employ the positional cue in this series, despite the rigorous control of this primitive tendency in all the previous series, seems to suggest that those highly trained subjects accepted ("understood") Series VI as an entirely new situation, both in visual pattern and motivation, thus supporting the conclusion reached on Form Preference (see page 43). In any event, the trained subjects exhibited a type of behavior which obviously required the least amount of action under the circumstances; whereas the Control subjects reacted in a typically untrained, diffuse, indirect, "chance" manner. The difficulty of *general* adaptation in this group increased markedly with chronological age.

d. Oral Behavior

The scores in oral behavior for the Experimental and Control subjects are very similar, even though the former group exhibited a slightly larger amount than the latter. The Control subjects, on the other hand, showed a higher incidence of "special" oral behavior (oral behavior without block contact). This difference is apparently due to a difference in the training and experience of the two groups of subjects, since the gustatory reward was an auxiliary motive for the trained group.

e. Vocalization

On the whole, the Control subjects were more vocal than the Experimental subjects with the vocalization type reflecting their general lack of adjustment to the situation. Of the total amount of vocalization exhibited, the trained group had accordingly a much higher percentage of vocalization of pleasantness. The untrained subjects, on the other hand, exceeded the trained ones in the percentages of vocalization of unpleasantness and of communication.

f. Affective Concomitant

In affective concomitant, as in vocalization, the Experimental subjects exceeded the Control subjects in the relative proportions of pleasant and very pleasant affective concomitant. They were exceeded by the Control subjects in neutral, unpleasant and very unpleasant affective concomitant.

Taking into consideration all the data on reaction time, manipulation, vocalization and affective concomitant, it is evident that the trained subjects, except in the one critical matter of form choice, gave conclusive evidence of positive transfer of previous training. This was objectively evident in superior regard and sustained attention, direct approach, short reaction time, and affective adjustment to the stimulus patterns in particular and the total experimental situation in general.

GENERAL DISCUSSION

A. SPACE PERCEPTION

The perception of visual form is obviously related to the basic problems of space perception in general. Since all general space perception theories directly or indirectly assume certain genetic hypotheses, it may be of final interest to touch briefly upon such correlations as our data afford. Thus, the older nativistic school [Descartes (1596–1650), Kant (1724–1804), Fichte (1762–1814), Johannes Müller (1801–1858), Hering (1834–1918), Stumpf (1848–1936), etc.] assert that the capacity to appreciate space is innate and may be used without preliminary practice. For them space offers no empirical problems; it is appreciated at once. Their major discussions and experiments deal with depth or distance, but since they do not state otherwise, we may assume that this hypothesis holds also for form.

Genetic data from this experiment which seem to accord with the nativistic concept are: (1) persistent and consistent individual differences in form discrimination *within* a given series despite identical training; (2) the ability to discriminate, even at the six months level when the optical apparatus is probably still somewhat immature (13, pp. 584–608), such fine differences as circle-oval; (3) the apparent "absolute" nature of form as evident in the small percentage of difficulties produced through changing size, contour, orientation, position and total pattern complexity; and (4) the close resemblance between the Experimental and Control Groups in their spontaneous selection of compound form blocks which, on the whole, seems to support "immediate" perception of these figures as "new" configurations.

The empiricists [Berkeley (1685–1753), Lotze (1817–1881), Helmholtz (1821–1894), Wundt (1832–1920), etc.] assert that the notion of space is developed through experience, and that therefore it is essential to discover the components of the idea of space and also to determine its origin. They are of the opinion that the nativistic theory is unnecessary and gratuitous, and that the development of space perception in experience is to a certain extent demonstrable.

Opposed to the strictly nativistic hypothesis and supporting the empirical concept are the evidences of practice and learning in form discrimination: (1) Superior discrimination performance was clearly present at the end of the experiment as compared with large number of trials and long reaction time in the early learning series. This could, of course, be attributed to general maturation except for the obvious differences between older trained subjects and beginning subjects of identical age. Furthermore, as these differences decreased rapidly with training, they can hardly represent innate maturational perception differences alone. (2) Since Subgroups I and II of the Experimental Group were equated in both physical and mental development, the various differences in results on form discrimination between the two subgroups were undoubtedly due to the difference in training, i.e., in the order of presentation of the stimuli.

Since Munn and Stiening (43) used only one subject, it is impossible to prove here what nevertheless is an obvious inference through comparing their data with ours; that is, requiring as many as 350 trials to learn to discriminate a cross from a square at the age of fifteen months might have been due to (1) poor form discrimination (an individual difference), (2) poor learning capacity, and (3) deprivation of the normally present manipulatory cues. Assuming the last possibility listed above on the basis of Munn's and Stiening's own description, one would then have additional data supporting the empiricists' belief that visual space percept, form or distance, is the product of many contributing senses, especially tactual manipulation. On the other hand, Révész (45) and other experimenters regard the development of tactual and visual form discrimination as parallel processes, i.e., independently maturing capacities.

On the whole, data from Series VI may be here interpreted as rather against the empiricists, since they fail to show any of the specific "trace" effects which could be logically anticipated from the long training in Series I–V.

Finally, it is quite conceivable that the effects of training in Series I–V represent trained *attention* to form differences, rather than improved form discrimination capacity *per se,* although "behaviorally" it would be quite as impossible to separate these two functions in an adult, as in these infants.

On the basis of the present investigation, it seems probable that space perception, as we find it even in the young infant, is the combined result of both inborn maturational capacities and individual experiences. Like all genetic studies, the results of this one point backward to still younger age levels, as far as the question of innate or acquired perceptual patterns are concerned. In this study the lower limit of six months was arbitrarily selected because of three reasons: (1) a mass of standardized data regarding normal eye-hand behavior patterns at this age, providing basis for legitimate technique; (2) the known maturation level of the physiological optical processes;[8] and (3) the almost universal implications in genetic literature that such perceptual discrimination of geometric form as we have measured would be quite impossible at six months (see Introduction, pp. 3–4). Having provided the first exact quantitative and qualitative data for geometric form discrimination at this age, it is now clear that some technique must be devised to study the same phenomenon in much younger infants. Similarly, a subsequent study must isolate all possible parallel or auxiliary cues, both manipulatory and gustatory cues.

---

[8] It is a well known physiological fact that the distal portion of the optic nerve is completely myelinated at six months, even though myelination of the entire nerve does not take place until the end of the first year. Also at the sixth month, binocular coördination becomes increasingly efficient; refraction is improved be-

In "Configuration" theories form perception as such is of special significance, as its name so clearly implies. Likewise the genetic aspects are of fundamental importance. Compare such conflicting statements as those of Koffka (36) and Stern (55) on the nature and level of "primitive figure-ground" relationship:

Koffka (36) writes:

> Very early the child turns toward bright objects, and begins to react differently to light and darkness. In this connection it should be noted that light and dark are not really color-designations, such as black and white, but instead indicate differences in the "level" of the surroundings. All we can properly say is that a bright object may stand out readily from its "background" at a very early age (36, pp. 265–266).

Stern (55) states:

> We must think of the earliest condition as one of entirely diffuse general sensibility. . . . We must first ask how the child in any way manages to distinguish and isolate a single phenomenon out of the confusion of this general condition. . . . Motor movements and concentrated attention are the two means by which the young creature selects and retains separate elements from the original confused chaos of outer sensations, and immediately separates them from that general condition and reserves them as a special experience. Gradually they assume

---

cause of the increased curvature of the cornea; the size of the pupil increases noticeably; and the lens gains both in thickness and degree of curvature. About the same age level, the optical axis increases greatly in length, the surface of the retina in size, and the cones in number. Foveal fixation, too, seems definitely established; therefore beginning from the sixth month, the infant is optically ready for this type of experimental task whereas children of younger age levels are conceivably not (13, pp. 584–608).

> thus a character opposed to merely subjective experiences, they point outward to things—in short, they become perceptions. Only this process is a very gradual one. . . . If we consider more closely the result of this process we see it is not now the sum, so to speak, of its component simple sensations. The image standing out from the background of consciousness (mother, rattle, etc.) is rather, from the beginning, a whole, within which single tones, lines, colors, etc., only have significance as mutually dependent, necessary component parts of that whole. Such a defined whole new psychology calls a psychic "form," and the formation, and the organization of the parts its "structure," (55, pp. 102 and 106).

Apropos of this theoretical confusion our data show that the finer capacities in form discrimination, i.e., specific geometric *detail* within a "mass-pattern" as opposed to mere "brightness discrimination," are present at very early age levels, much earlier than is admitted anywhere in the literature with the possible exception of the work reported by Volkelt (60). They are *not*, as so frequently labelled by others, an "advanced" form of mental activity emerging "relatively late" from a more primitive "diffuse" state, though the term "relatively late" is certainly indefinite enough. Furthermore, these objective differences (sensory cues) within a given pattern may be quite minute without being easily obscured or "absorbed" by the "Gesamtheit Charaktur" of a "primitive" level of perception, "vague, fluid, inaccurate, and liable to modification in accordance with *subjective* tendencies" (58, p. 178). Finally, the nature of the young infant's discrimination of geometric forms is not sufficiently "vague, diffuse and homogeneous" to be very easily affected by changes of the whole through modification of such vital collateral (i.e., "topological," "geographical") parts as spatial orientation, size, number, grouping, sequence, etc.

The present study seems not only to confirm the general opinion of Koffka (36), Vernon (58), Gellermann (15, 16), Bühler (4), etc. that to a young child a form is much more independent of its absolute spatial position than it is to adults (cf. pp. 1–2), but also to show that this is marked in early infancy. On the other hand, this "independence," while preponderant, is still relative and not absolute, as a literal inference of this genetic theory might imply.

The present findings do not confirm Jersild's widely accepted doctrine that "a young child is likely to make errors by judging objects in terms of their size rather than their form" (31, p. 237). They confirm Koffka's (36) and Stern's (55) statements that size plays a very insignificant rôle in the recognition of things in early perceptual stages (36, p. 288; 55, p. 121), (cf. p. 2).

The results here show that within a multiple, i.e., "synthetic" [Krasnogorski (39)] pattern of not more than five units, an increase in the number of blocks presented simultaneously rendered the task of form discrimination more difficult but not impossible for the infants. Data from Series IV ("Increase in Number") show that the task of "abstracting" the circle (positive stimulus) from a new "synthetic" pattern was more difficult when the form in question was placed next to the oval (similarity plus proximity) than away from it (similarity only), or when it was in or near the center of the pattern than on the ends. The task was hardest if the circle was placed at the center next to the oval. These results seem to confirm Schroff's (49) and Rush's (48) finding that similarity and proximity are among the factors which exert a powerful influence in visual grouping (see p. 2).

Except in the multiple series the present study shows, however, that position played a very insignificant rôle in the form discrimination of the infants. In Series I, II, III and V they learned very rapidly to dispense with it. It is, however, interesting that a few subjects, when confronted with abrupt changes in the experimental set-ups in the first parts of Series V ("Learning in Reversed Order"), tended to resort, during their temporary confusion, to an obvious positional cue, a primitive tendency familiar to all who work in animal psychology.

Listing these "geographical" details in approximate order of decreasing effect on performance, but keeping in mind the relatively *small* effect of all of them, one finds that they are: (1) number, (2) similarity, (3) sequence, (4) proximity, (5) size, (6) spatial orientation and (7) position.

As directly or indirectly related to such factors in perception as "goodness of contour," "potency" of contour, interest, or even the physiology of vision, the spontaneous response to or selection of the different geometric contours under different pattern conditions seems of interest here. From this experiment it appears that angularity was one of the primary cues in the form discrimination of the infants. An abrupt withdrawal of this cue rendered the task much more difficult; however, the infants were able to dispense with it when it was not available. From an arbitrary point of view it might be assumed that the primitive "goodness" of the circle, being the simplest of the forms to be perceived by a "primitive" six-month intelligence, might be translated into a simple, "primitive" motor preference. From another point of view, possibly correlated with physiological determinants—roundness of fovea, macula, pupil, etc.—as projected undifferentiated "mass" patterns, the circle is perhaps *too* primitive a contour to be perceptually interesting, and any *change* might therefore focus the infant's visual attention. This is in accordance with the general principle that we react primarily rather to *change* from or within a familiar or habitual stimulus than merely to the stimulus itself [Jenkins (30), Crudden (7), etc.]. On this hypothesis, spontaneous preferences would select the non-circle forms. The actual data show that in the first part of Series I when the circle was the positive stimulus and the cross (for Subgroup I) or the oval (for Subgroup II) the negative, not a single subject in either the Preliminary or the Experimental Groups learned to select the circle as against either of the other two forms in the first ten trials (the minimal number of trials required by the experiment). In fact, a few of the subjects spent as many as 100 trials or more before they stopped attempting to acquire the cross or the oval. Again in Series VI when spontaneous selection was allowed, in an overwhelming majority of the cases both the trained and untrained subjects showed slight but consistent preference for the non-circle to circle forms. These results would seem to indicate that instead of preferring the form which is the simplest both "geographically" and "behaviorally," the young human infant tends to select more complex geometric forms; such as the cross, triangle, square and oval, as opposed to the circle.

From the preceding discussion it is clear that these genetic data at least partly agree with certain aspects of all the three theories of space perception in question. With the general concepts of Koffka (37) and Vernon (58) as expressed in the following paragraphs there seems to be a general agreement.

Thus Koffka (37) writes:

> It will not be necessary to point out that an anti-empiristic attitude does not mean the denial of the enormous value of experience. Not *that* it makes use of experience causes our objection to empiricism, but *how* it makes use of it (37, p. 639).

Again Vernon (58) states:

> But we must remember that our apprehension of space is not dependent only upon the pattern of visual stimulation. A configurational structure such as we have described is essentially bound up with a mass of kinaesthetic and proprioceptive sensory data, with postural schemes of the kind described by Head, and with visual and kinaesthetic ideational data derived from individual experience. To the latter we have frequently alluded. The former are not exactly within the scope of this book; but we shall consider their relationship to the visual spatial configuration in Chap. X, in connection with the 'spatial framework.' We may, however, suggest that there is a definite schematic relationship between all these factors, the development of which is a purely spontaneous perceptual process, although its form is influenced by the factors of experience which we have mentioned. The ability to create structures of this kind, and to utilize more or less adequately the data which they afford, is an innate property of the organism. But the completeness and detail of a structure and its modifications under different conditions, objective and subjective, must be affected and to some extent determined by individual experience; and so also the particular accuracy and efficiency with which the individual can deal with any particular aspect of the structure and deduce from it any particular relationship of depth or distance (58, pp. 87–88).

In spite of a general ideational agreement, our experimental data definitely disagree with the tempo of development as emphasized by these two authors.

B. LEARNING

As the experimental situation in the present study obviously involves some general questions of trial-and-error learning, viz., association, both in the classical sense of contiguous pattern, and in the sense of Conditioned Reflex; "insight" or sudden learning in the Köhler-Gottschaldt sense; positive transfer of training; various phenomena of inhibition; as well as such mechanical aspects as number and order of repetitions, forward and backward learning, facilitation, extinction, etc.; some genetic aspects of these factors in learning may be briefly outlined here.

At least within this controlled experimental situation the following general statements hold true:

1. With the exception of the circle-oval combination, the number of repetitions required for the successful discrimination of the cross, the triangle, or the square from the circle seemed to depend more upon the general order of presentation of the stimuli than upon the degree of similarity which each of these forms bore to the circle. In the case of the circle-oval combination, however, the close similarity between the two forms rendered the task of discrimination markedly harder than in the case of of any other form combination used in the present study (see Tables 2 and 3 on pages 18 and 19 respectively).

It seems probable, therefore, that angularity versus non-angularity (or circularity versus non-circularity) was the "critical" or basic discriminatory clue, regardless of how small or how large this difference was. Since there is very little difference in the curves for the square, triangle, and cross (contrary to expectations), it seems obvious that the range of geometric forms used in this experiment does not actually test the *maximum* capacity of these infants in fine discrimination. Superimposed upon our quantitative data, this general result in itself is a significant corroboration of our hypothesis that the finer processes of perceptual discrimination, as opposed to the "diffuse" or "mass," unindividuated nature of primitive perception, are certainly present in the six months human infant. A subsequent study will try to determine the "absolute" limits of fine discrimination within a basic circular, and a basic angular, geometric figure.

2. On the whole, an increase in the number of form units composing the stimulus pattern from two blocks on made the task of discrimination more difficult. However, increase in number did not bear a straight-line relationship to the difficulty of the task, as measured by the combined scores in total number of trials, percentage of success, and total and average reaction time. Rather it produced very different effects on different individuals.

3. Individual differences in the learning of the various form combinations were both consistent and marked as shown by the scores in total number of trials (range: 297–1024 trials), percentage of success (range: 86.20−%–57.03+%), and total reaction time (range: 2123.5–20009.0 sec.).

Among the most conspicuous of individual differences were "types" of learners. Thus, in the Regular Experimental Group of eighteen subjects, three were fast and efficient learners, two fast but inefficient, three slow but efficient, three slow and inefficient. The remaining seven were "average" in their learning efficiency, and high, medium or low in speed. The coefficient of correlation between quality and rapidity in learning for the group was +.25±.15 (cf. page 24). These "type" differences were generally apparent very early in the experiment and remained consistent throughout.

On the whole, the fast and efficient learners made the most rapid adjustment in the first form combination of Series V. The fast and inefficient subjects might give, superficially, a false impression of rapid initial adjustment, but they were never stable in the adaptation. The slow and efficient infants, on the other hand, might take a relatively long time to scrutinize the changed situation; but once the change was "cognized," the motor task was completed. The slow and inefficient learners had a great deal of trouble both in recognizing the reversal in the functional relationship of the two units of the stimulus pattern, and in adapting themselves to the new experimental condition. They spent as many as 70 to 130 trials in learning the form combination. It seems apparent, therefore, that the difficulty among those infants was primarily a *perceptual* one, with little reference to motor capacity. The medium cases, as one would expect, lay intermediate between these four extreme types in their ability to detect the change and in the permanency of the new habit. Detection of such highly consistent "types" at these very early age levels would seem to emphasize the constitutional, as opposed to the purely environmental factors, in the genesis of the learning process.

4. Trial and error was of necessity used by all the subjects in the learning of the initial form combination. After a number of futile attempts (range: 6–218 trials) to secure the negative block, these unsuccessful movements were "stamped out"; only those responses leading directly to the acquisition of the positive form were retained (Thorndike's Laws of Effect and Exercise; Professor Shepard's explanation that the learning was effected by the organism's accidental attention to the *proper* stimulus).

5. Positional cues were used by a few subjects at the beginning of the experiment. However, these subjects soon learned to dispense with these cues and resorted to using them again only when temporarily confused, such as in the first form combination of Series V. This is a primitive or "regressive" tendency pointed out in many of the animal experiments.

6. Definite signs of one total pattern inhibiting another were shown by the subjects on such occasions as: (*a*) in the first form combination of Series V when there was an abrupt reversal of functional relationship between the positive and negative stimuli; and (*b*) in the first part of Series VI in which compound blocks, made of a negative form superimposed on a positive form, or vice versa, were exposed. Under such circumstances *some* of the trained subjects seemed to be at a loss as to what to do about the blocks.

7. Evidence of a positive general transfer of training can be found throughout the experiment after the first form pattern, in that the subjects spent less time and had less trouble in learning any subsequent forms. This type of general transfer was most obvious in Series VI when the behavior of the Experimental Cases was compared with that of the Control Group. Such a comparison showed, first of all, a far superior general adaptation

on the part of the trained subjects to an environment which was at once strange and highly artificial. These infants were more amiable, interested and quiet, and were willing to work for a much longer period of time than untrained subjects. Second, they paid more immediate and selective attention to the stimulus pattern, both to the whole and to the parts. There was definite inhibition of extraneous bodily movements. Visual regard was of an anticipatory, "critical" and sustained type, and was directed to details often unnoticed by untrained subjects. Third, they showed a more direct and accurate motor approach to the units of the stimulus pattern. Having secured the block, their manipulative activities were more varied, and their visual-tactual examinations more minute. Finally, it has been repeatedly pointed out by their parents that these trained subjects developed a smoother adaptation to various "lay" situations within the home, implying a very *general* type of transfer.

8. The results of the present study show that, contrary to much modern emphasis, especially in educational psychology, on learning performance as a product of the "whole" personality, form perception as such, and this type of learning performance as such, seem relatively independent of specific constitutional temperamental differences and their affective concomitants. Nor is there any evidence in our data that learning performance at the infant level is necessarily *more* of a primitive emotional activity than at the higher age levels (apropos of the hypothesis that the younger, i.e., more primitive, the organism, the more its behavior is dependent on the diffuse or unspecific "mass activities" of the "whole" organism, and the more preponderant the "vegetative" levels of emotional motivation). These seem, even at this very early age level, to be *subsidiary* concomitants and not the major determinants of learning achievement of this form-discrimination type. This implies no under-estimation of the "dynamics" of behavior, but does seem to stress that even in very young infants, they are controllable variables of a given process, rather than the process itself.

9. Results on achievement, plotted on the basis of each day, show that plateaus are present in a number of learning curves.

These plateaus may be explained on any or all of the following bases:

a) When the subject was baffled by a difficult discrimination pattern. A few noticeable examples of such patterns were the circle-oval combinations, particularly when the oval was turned ninety degrees to the right, the multiple patterns, and the first form combinations of Series V.

b) When there was a temporary loss of interest due to lowered motivation (see 10 below).

c) When perseveration or integration of what had been learned was going on (classical interpretation).

10. Compared with the various studies of form discrimination listed in the Introduction (see page 1), it seems that the more positive findings of the present investigation were, in a large measure, due to the selection of proper motivating factors. The brightly colored blocks of appropriate manipulatory sizes, their saccharine coating, and the simplicity of bodily action correlated *specifically* with the sensorimotor development and involuntary action tendencies (viz., grasping, manipulation and oral behavior) of infants between six and twelve months of age. After the twelve months level, however, the motivating factors had to be made slightly more complex in further accordance with genetic development.

11. "Insight" or sudden learning in the Köhler-Gottschaldt sense seemed clearly demonstrated in the learning of the first form combination of Series V by at least four of the total eighteen subjects of the Regular Experimental Group. After one or two preliminary attempts to dislodge the circle, the subject, accidentally or deliberately, turned to the previously negative form, and much to his apparent surprise, it was easily removed. This situation produced temporarily a careful examining behavior. Then suddenly he seemed to perceive that the component units of the stimulus pattern had been functionally reversed. From that moment on his facial expression relaxed; the fretful, bewildered vocalization was promptly replaced by a cheerful and contented one; and he seldom or never returned to the once highly motivated circle. This absence of stereotypy seems

rather striking evidence of a far more plastic adaptive behavior in infants than the mechanistic concepts of the Conditioned Reflex School, as extinction or backward learning, permit. It is true, of course, that this behavior may be explained in more mechanistic terms. Its qualitative aspects, however, lead us to place it rather in the same category as other "Substitution" tests [Volkelt (60)], the obvious substitution being, here, a reversed functional relationship. It seems likewise very significant that in the same situation, severe rachitic and congenitally retarded infants of the same age levels never perceive this reversed function, and must go through a tedious process of backward learning, or experimental "extinction"—often longer in duration than the initial learning [Colby (6)].

12. The controversial term "abstraction" is used here in its own original or genetic sense of the separation and "lifting" of a common factor or factors from the total configuration. According to such interpretation by Werner, it is a process "quite close to primary sensory organization" (62, p. 357), in which a limited aspect or aspects of the situation are responded to at the exclusion of all others, and in which "things having equal qualities tend to come to the fore, organizing themselves into a unit" (62, p. 357). "Abstraction" is therefore used here in Munn's (43), Field's (14), and Gellermann's (15, 16) sense and is what Werner calls "primitive abstraction" (62, p. 357), as opposed to the interpretation of Smith (53, 54), Klüver (35), and many others.

Throughout the first three series of experiments the infants gave unequivocal evidence of their ability to respond positively to form *per se*, regardless of relative position, size, or the spatial orientation of the various forms. In Series IV they demonstrated conclusively that they were capable of "lifting" a single contour from a multiple pattern of three, four and even five different geometric forms. In Series V some subjects (better learners) succeeded almost instantaneously in "abstracting" the changed functional relationship within a pattern of highly conditioned stimuli while the poorer learners tended toward the stereotypy characteristic of unconditioning, or backward learning.

SUMMARY AND CONCLUSIONS

This experiment studies geometric form discrimination as a learning cue in infants of six to fifteen months of age. It is fourfold in its purpose:

1. To determine the nature and extent of geometric form discrimination in infants;
2. To study the efficacy of such discrimination as a cue in the various phases of the learning process;
3. To analyze *quantitatively*, for the first time, all the dynamic, qualitative concomitants involved;
4. To trace, by continuous *longitudinal* experimentation, as opposed to the sampling method, the finer phases of chronological maturation as related to the foregoing processes.

The main study consisted of six series of experiments as follows:

Series I	"Forward Learning"
Series II	"Change in Spatial Orientation"
Series III	"Change in Size"
Series IV	"Change in Number"
Series V	"Learning in Reversed Order"
Series VI	"Compound Block Situation"

Throughout the first five series a simple conditioning technique was used. In the last series, since it studied the possible effects of combining or masking the geometric forms learned in Series I–V, spontaneous selection was the method used, and the subjects included a control group of untrained infants.

The results of the experiment, which consisted of both mechanically recorded and protocol data, were analyzed on the basis of both achievement and development. From these results the following general conclusions have been drawn:

A. PERCEPTUAL PROCESSES

1. The normal human infant is able to discriminate between simple geometric forms as early as six months of age.
2. At this age level the normal human infant is also able to use fine geometric form discrimination *per se* as a learning cue, establishing definite selection and avoidance habits.

3. Individual differences in discrimination processes (including "abstraction"), learning ability, and affective concomitants, are very marked and consistent at every age level and in every series.

4. Change in the relative position, spatial orientation, or size of either or both positive and negative stimuli has a very slight effect on the discrimination performance of the infant.

5. Increase in the number of blocks presented simultaneously (increase in the complexity of the total pattern) from two on to five renders the discrimination more difficult. However, this increase in number does not bear a straight-line relationship to the difficulty of the task.

6. Within a multiple pattern of three to five blocks the task of "abstracting" the positive stimulus from the total configuration is more difficult when the stimulus is adjacent to a closely similar form (similarity plus proximity) than when away from it (similarity only); also when it is in or near the center of the pattern than when it is on the ends. The task is hardest if it is placed at the center of the pattern next to a closely similar form.

7. Sudden reversal of functional relationship between positive and negative stimuli causes temporary confusion both in selecting behavior and in affective concomitant. However, such disturbance subsides very soon and, in the case of at least twenty-two per cent of the subjects, with apparent "insight."

8. The sequence or order of presentation of the geometric form patterns has a marked influence over the learning performance of the infant. Presentation in a descending order of difficulty, i.e., from most similar to most dissimilar form combinations, makes the initial learning relatively harder, but apparently prepares the subject more adequately for more difficult tasks at a later time by training him to notice fine differences from the start. Presentation of stimuli in an ascending order of difficulty, i.e., from most dissimilar to most similar form combinations, has an opposite effect.

9. Positional cues are apparently sought by some subjects at the beginning of the experiment. However, these infants soon learn not to rely on these cues and resort to using them again

only when temporarily confused, such as in the first form combination of Series V.

10. Definite signs of one *total* stimulus pattern inhibiting another are shown by all the subjects in the first form combination of Series V when there is an abrupt reversal of functional relationship between the two units of the stimulus pattern, and by some trained infants in the first part of Series VI when compound blocks, made of a negative form superimposed on a positive form, or vice versa, are exposed for the first time.

11. In the approximate order of decreasing potency the "geographical" factors which affect the discrimination performance in the present study are: (1) number, (2) similarity, (3) sequence, (4) proximity, (5) size, (6) spatial orientation and (7) position. None of these factors, however, has a critical effect on performance.

12. Data from Series I and VI show that the young human infant tends spontaneously to select (i.e., to "prefer") the more complex angular forms as opposed to the "primitive" circle form.

B. LEARNING PROCESSES

1. Trial-and-error method is imposed by the experimental procedure in learning the first form combination in Series I, and again in the first form combination in Series V. With these exceptions, selection *without* trial and error is theoretically possible in all other trials. However, with one possible exception, no infant in the present study showed such complete positive transfer. The amount of trial and error in subsequent trials varied enormously with the individual infant and was inversely correlated with the presence or absence of "insight."

2. These individual differences classify the infants rather specifically into the same five general "types" of learners as occur among adults. These fluctuate little from day to day over a long experimental period of several months.

3. Plateaus occur in about one fourth of the learning curves and seem to correlate with the difficulty of the individual task and temporary fluctuations in interest and attention. The post-plateau rise of most of these curves would imply some kind

of perseverative gain rather than loss in learning during the plateau period.

4. The combined results on achievement and development show that the success of an experiment of this type depends, in a large measure, upon the careful selection of appropriate motivating factors which must appeal powerfully to the predominant drives and lie within the sensorimotor capacities of a given age level.

5. Analysis of data on the basis of development seems to show that, with the type of task provided in this study, the infant's interest and efficiency in learning increase steadily from the seventh to the eleventh or twelfth month of age. After that there is a plateau or even a definite decrease due mainly to the extremely rapid maturational rate between eleven and fifteen months. This acceleration in development causes the older infant to disdain the very simple form patterns which, in turn, necessitates some slight increase in the complexity of the stimulus situation in order to maintain the same degree of appeal to the subject throughout the entire experiment.

6. Data analyzed on the basis of development show that all the subjects of the Experimental Groups can be divided, according to their hand preference, into three distinct types: (1) the predominantly right-handed individuals, (2) the predominantly left-handed individuals, and (3) individuals who shift from the predominant use of one hand to that of the other from month to month in a rhythmical sequence.

7. Handedness in a given infant does not seem to bear any consistent or significant relationship with his ability as a learner, or his interest in the task, or with the difficulty of the task.

8. Comparison of data on Series VI between the Experimental and Control Groups shows that when presented with blocks compounded of both positive and negative forms, the trained subject behaves very much like the untrained in spontaneous selection. This may possibly indicate that the trained infant perceives this compound block situation as a totally new Gestalt. On the other hand, it may simply mean a more complex, and therefore a more "interesting," stimulus without regard to past

"conditioning." Evidence for final interpretation of this series is not yet complete.

9. The results of Series VI do, however, give clear evidence of positive transfer of training in other specific experimental "habits," viz., superior visual "regard," sustained attention, direct manual approach, short reaction time, and affective adjustment both to the stimulus patterns in particular and the total experimental situation in general.

10. Both affective concomitant and vocalization, although so widely used as objective criteria for the apparent difficulty of a given task and the subject's success in it, appear from this study to have no correlation with achievement scores.

11. Data on oral behavior seem to confirm the interpretation of "mouthing" by Stern (55) and others as a relatively universal and stereotyped tactual experience in the development of spatial qualities. Whatever be the interpretation of this form of behavior, it is a dynamic concomitant clearly related in early infancy to the difficulty of a given task. Enhancing this spontaneous tendency with a gustatory reward serves merely to intensify a natural motivation factor.

12. If by abstraction is meant the capacity to respond to: (1) form *per se*, regardless of size, orientation, position, sequence, or pattern complexity; and (2) abruptly changed functional relationship between the two highly conditioned units of a stimulus pattern; then this experiment may be said to have demonstrated the presence of abstraction, or at least a "primitive" form of it, in human infants within the age levels studied.

BIBLIOGRAPHY

(1) Arlitt, A. H. *Psychology of infancy and early childhood.* New York: McGraw-Hill, 1928. Pp. vii + 228.

(2) Brian, C. R., and Goodenough, F. L. The relative potency of color and form perception at various ages. *J. Exper. Psychol.*, 1929, 12, 197–213.

(3) Brunswik, E., and Cruikshank, R. M. Perceptual size-constancy in early infancy. (Report in the 45th annual meeting of the Amer. Psychol. Assoc.) 1937, p. 18.

(4) Bühler, K. *Die geistige Entwicklung des Kindes.* (Vierte durchgesehene Auflage.) Jena: Fischer, 1924. Pp. v + 484.

(5) Castner, B. M. The development of fine prehension. *J. Genet. Psychol.*, 1932, 12, 111–191.

(6) Colby, M. G. Behavior in rachitic infants. (Unpublished.) Children's Fund, Detroit, Mich., 1936.

(7) Crudden, C. H. Symmetry and asymmetry in form abstraction by children. (Doctor's thesis in psychol., Univ. Mich., General Library.) 1937.

(8) Curti, M. W. *Child psychology.* New York: Longmans, Green, 1932. Pp. vii + 527.

(9) Déscoeudres, A. Coleur, forme, ou nombre? *Arch. de Psychol.*, 1914, 14, 305–341.

(10) Djang, S. S. The rôle of past experience in the visual apprehension of masked forms. *J. Exper. Psychol.*, 1937, 20, 29–59.

(11) Fajans, S. Die Bedeutung der Entfernung für die Stärke des Aufforderungscharakters beim Säugling und Kleinkind. *Psychol. Forsch.*, 1933, 17, 215–267.

(12) Fajans, S. Erfolg, Ausdauer und Aktivität beim Säugling und Kleinkind. *Psychol. Forsch.*, 1933, 17, 268–305.

(13) Feldman, W. M. *The principles of ante-natal and post-natal child physiology.* London: Longmans, Green, 1920. Pp. vii + 694.

(14) Fields, P. E. Studies in concept formation. I. The development of the concept of triangularity by the white rat. *Comp. Psychol. Monog.*, 1932, 9, No. 2, 1–70.

(15) Gellermann, L. W. Form discrimination in chimpanzees and two-year-old children. I. Form (triangularity) *per se.* *J. Genet. Psychol.*, 1933, 42, 3–27.

(16) Gellermann, L. W. Form discrimination in chimpanzees and two-year-old children. II. Form versus background. *J. Genet. Psychol.*, 1933, 42, 28–50.

(17) Gesell, A. *The mental growth of the pre-school child.* New York: Macmillan, 1926. Pp. v + 447.

(18) Gesell, A., and Thompson, H. *Infant behavior: its genesis and growth.* New York: McGraw-Hill, 1934. Pp. v + 343.

(19) Gesell, A., and Thompson, H. *The psychology of early growth.* New York: Macmillan, 1938. Pp. v + 290.

(20) Gesell, A., Halverson, H. M., Thompson, H., Ilg, F. L., Castner, B. M., Ames, L. B., and Amatruda, C. S. *The first five years of life: a guide to the study of the preschool child.* New York: Harper, 1940. Pp. v + 393.

(21) Giesecke, M. The genesis of hand preference. *Monog. Soc. Res. Child Develpm.*, 1936, 1, No. 5, vii + 102.

(22) Gottschaldt, K. *Der Aufbau des kindlichen Handelns. Vergleichende Untersuchungen an gesunden und psychisch abnormen Kindern.* Leipzig: Barth, 1933. Pp. vii + 227.

(23) Halverson, H. M. Complications of the grasping reaction in young infants. *Psychol. Bull.*, 1935, 32, 692.

(24) Halverson, H. M. An experimental study of prehension in infants by means of systematic cinema records. *Genet. Psychol. Monog.*, 1931, 10, 107–286.

(25) Halverson, H. M. A further study of grasping. *J. Gen. Psychol.*, 1932, 7, 34–64.

(26) Hanawalt, N. G. Memory trace for figures in recall and recognition. *Arch. Psychol.*, 1937, 216, 1–89.

(27) Hanfmann, E. Some experiments on spatial position as a factor in children's perception and reproduction of simple figures. *Psychol. Forsch.*, 1932–1933, 17–18, 319–329.

(28) Hetzer, H., Beaumont, H., and Wiehemeyer, E. Das Schauen und Greifen des Kindes: Untersuchungen über spontanen Funktionswandel und Reizauslese in der Entwicklung. *Zsch. f. Psychol.*, 1929, 113, 268–286.

(29) Irwin, O. C. The amount and nature of activities of newborn infants under constant external stimulating conditions during the first ten days of life. *Genet. Psychol. Monog.*, 1930, 8, No. 1, 1–92.

(30) Jenkins, W. L. Adaptation in isolated cold spots. *Amer. J. Psychol.*, 1937, 49, 1–22.

(31) Jersild, A. T. *Child psychology.* New York: Prentice-Hall, 1933. Pp. vii + 462.

(32) Johnson, B. J. *Child psychology.* Springfield: Thomas, 1932. Pp. vii + 439.

(33) Katz, D. *Der Aufbau der Tastwelt.* Leipzig: Barth, 1925. Pp. vii + 270.

(34) Katz, D. *Die Erscheinungsweisen der Farben und ihre Beeinflussung durch die individuelle Erfahrung.* Leipzig: Barth, 1911. Pp. vii + 425.

(35) Klüver, H. *Behavior mechanisms in monkeys.* Chicago: Univ. Chicago Press, 1933. Pp. xvii + 387.

(36) Koffka, K. *The growth of the mind.* (Translated by R. M. Ogden.) New York: Harcourt, Brace, 1925. Pp. v + 383.

(37) Koffka, K. *Principles of Gestalt psychology.* New York: Harcourt, Brace, 1935. Pp. ix + 720.

(38) Köhler, W. *The mentality of apes.* (Translated from the 2nd revised edition by E. Winter.) New York: Harcourt, Brace, 1925. Pp. v + 342.

(39) Krasnogorski, N. I. Neue Ergebnisse der Erforschung der physiologischen Tätigkeit des Gehirns im Kindesalter. *Jahrb. f. Kinderheilk*, 1935, 144, 255–277.

(40) Kuenburg, M. G. von. Über Abstraktionsfähigkeit und die Entstehung von Relationen beim vorschulpflichtigen Kinde. *Zsch. f. angew. Psychol.*, 1920, 17, 270–312.

(41) Lewin, K. *Principles of topological psychology.* (Translated by F. Heider and G. M. Heider.) New York: McGraw-Hill, 1936. Pp. vii + 231.

(42) Line, W. The growth of visual perception in children. *Brit. J. Psychol. Monog. Suppl.*, 1931, 5, No. 15, 1–148.

(43) Munn, N. L., and Stiening, B. R. The relative efficacy of form and background in a child's discrimination of visual patterns. *J. Genet. Psychol.*, 1931, 39, 73–90.

(44) Rabello, S. A percepção das côres e das formas entre as crianças de 3 a 11 annos. (Color and form perception in children of three to eleven years.) *Bol. Educ., Pernanbuco*, 1933, 16–45.

(45) Révész, G. System der optischen und haptischen Raumtauschungen. *Zsch. f. Psychol.*, 1934, 131, 296–375.

(46) Rice, C. The orientation of plane figures as a factor in their perception by children. *Child Development*, 1930, 1, 111–143.

(47) Romero, D. E. The relation of visual form discrimination to learning in nursery school children. (Master's thesis in Educ., Univ. Mich., Elementary School Library.) 1935.

(48) Rush, C. P. Visual grouping in relation to age. *Arch. Psychol.*, 1937, 217, 1–95.

(49) Schroff, E. Über Gestaltauffasung bei Kindern im Alter von 6 bis 14 Jahren. *Psychol. Forsch.*, 1928, 11, 235–266.

(50) Segers, J. E. Recherches sur la perception visuelle chez des enfants agés de 3 à 12 ans et leur application à l'éducation. *J. de Psychol. Norm. et Pathol.*, 1926, 23, 608–636 (Perceptions simples); 723–753 (Perceptions complexes).

(51) Shinn, M. W. Notes on the development of a child. II. The development of the senses in the first three years of childhood. *Univ. Calif. Publ. Educ.*, 1907, 4, 1–258.

(52) Skeels, H. M. A study of some factors in form board accomplishments of preschool children. *Univ. Iowa Stud.: Stud. in Child Welfare*, 1933, 7, No. 2.

(53) Smith, K. U. Visual discrimination in the cat. I. The capacity of the cat for visual figure discrimination. *J. Genet. Psychol.*, 1934, 44, 301–320.

(54) Smith, K. U. Visual discrimination in the cat. II. A further study of the capacity of the cat for visual figure discrimination. *J. Genet. Psychol.*, 1934, 46, 336–357.

(55) Stern, W. *Psychology of early childhood.* (Trans. fr. 3rd ed. by A. Barwell.) New York: Henry Holt, 1924. Pp. 1–557.

(56) Tobie, H. D. Die Entwicklung der teilinhaltlichen Beachtung von Farbe und Form im vorschulpflichtigen Kindersalter. *Zsch. f. angew. Psychol.*, 1927, Bd. 12, Beih. 38, pp. viii + 103.

(57) True, A. A study of the development of prehension in the northern colored infant. (Doctor's thesis in Psychol., Univ. Mich., General Library.) 1937.

(58) Vernon, M. D. *Visual perception.* New York: Macmillan, 1937. Pp. x + 247.

(59) Volkelt, H. *Fortschritte der experimentellen Kinderpsychologie.* Jena: Fischer, 1926. Pp. 1–52.

(60) Volkelt, H. *Neue Untersuchung über die kindliche Auffassung und Wiedergabe von Formen.* Berlin: Springer, 1929. Pp. 15–61.

(61) Werner, H. *Einfühlung in die Entwicklungspsychologie.* (Zweite Auflage.) Leipzig: Barth, 1933. Pp. iii + 432.

(62) Werner, H. Processes and achievement: a basic problem of education and developmental psychology. *Harvard Educ. Rev.*, 1937, 7, 353–368.

(63) Wertheimer, M. Untersuchungen zur Lehre von der Gestalt. *Psychol. Forsch.*, 1922, 1, 47–58; 1923, 4, 301–350; 1925, 7, 81–137.

(64) Weeler, R. H., and Perkins, F. T. *Principles of mental development.* New York: Crowell, 1932. Pp. vii + 529.

(65) Whiteside, S. Spontaneity of normal and mentally deficient subjects in selective learning. *Proceedings and Addresses of the 58th Annual Session of Amer. Assoc. on Mental Deficiency*, 1934. 1–41.

Continued from fourth cover

42. Studies in concept formation. By Paul E. Fields. Pp. 70, $1.25.
43. Conditioning finger retraction to visual stimuli near the absolute threshold. By Sidney M. Newhall and Robert R. Sears. Pp. 25, $.75.
44. The organization of learning and other traits in chickens. By Jack W. Dunlap. Pp. 55, $1.00.
45. The modification of vestibular nystagmus by means of repeated elicitation. By O. H. Mowrer. Pp. 48, $.75.
46. Mechanisms of handedness in the rat. By Geo. M. Peterson. Pp. 67, $1.25.

VOLUME 10

47. Modes of behavioral adaptation in chimpanzee to multiple-choice problems. By Robert M. Yerkes. Pp. 108, $1.50.
48. A field study of the behavior and social relations of howling monkeys. By C. R. Carpenter. Pp. 168, $2.25.
49. Auditory acuity of monkeys. By G. R. Wendt. Pp. 51, $.75.
50. The functions of the visual areas of the cerebral cortex of the rat in the learning and retention of the maze. I. By Yü-Chüan Tsang. Pp. 56, $1.00.

VOLUME 11

51. The comparative physiology of the conditioned motor reflex. By H. S. Liddell, W. T. James, and O. D. Anderson Pp. 89, $1.50.
52. Studies of cerebral function in learning. XI. The behavior of the rat in latch box situations. The mechanism of vision. XII. Nervous structures concerned in the acquisition and retention of habits based on reactions to light. By K. S. Lashley. Pp. 79, $1.25.
53. Eye-movement during visual imagery. By Edith Totten. Pp. 46, frontispiece, $.75.
54. The influence of concomitant activity and fatigue upon certain forms of reciprocal hand movement and its fundamental components. By David P. Boder. Pp. 122, $1.75.
55. Hemispheric cerebral dominance and hemispheric equipotentiality. By Samuel A. Kirk. Pp. 41, $.75.

VOLUME 12

56. The effects of cerebellar lesions upon the habituation of post-rotational nystagmus. By Ward Halstead. Pp. 130, $1.75.
57. The functions of the visual areas of the cerebral cortex of the rat in the learning and retention of the maze. II. By Yü. Chüan Tsang. Pp. 41, $.75.
58. The avian visual system. I. Cerebral functions of the domestic fowl in pattern vision. By John D. Layman. Pp. 36, $.75.
59. Infant behavior. By Mandel Sherman, Irene Sherman, and Charles D. Flory. Pp. 107, $1.50.
60. Effectiveness of token-rewards for chimpanzees. By John B. Wolfe. Pp. 72, $1.25.

VOLUME 13

61. Physique and psychosis, an analysis of the postulated relationship between bodily constitution and mental disease syndrome. By Edward M. L. Burchard. Pp. 73, $1.25.
62. Anticipatory responses in serial learning by chimpanzee. By S. D. S. Spragg. Pp. 72, $1.25.
63. Studies of cerebral function in primates. By C. F. Jacobsen with the coöperation of J. H. Elder and G. M. Haslerud. Pp. 68, $1.25.
64. The sensory basis of maze learning in rats. By C. H. Honzik. Pp. 113, $1.50.
65. Oestrus, receptivity, and mating in chimpanzee. By R. M. Yerkes and J. H. Elder. Pp. 39, $.75.
66. Motor performance of the deaf. By Joseph E. Morsh. Pp. 51, $1.00.

VOLUME 14

67. A test for measuring sexual excitability in the female rat. By Josephine Ball. Pp. 37, $.75.
68. The coöperative solving of problems by young chimpanzees. By Meredith P. Crawford. Pp. 88, $1.50.
69. Factors in rat learning: an analysis of the intercorrelations between 34 variables. By Charles L. Vaughn. Pp. 39, $.75.
70. The effect of voluntary activity on the knee-jerk. By Sarah C. Dunlap. Pp. 63, $1.25.
71. Food-tokens as incentives for learning by chimpanzees. By John T. Cowles. Pp. 96, $1.50.
72. The interrelationship of drives in the male albino rat. By E. E. Anderson. Pp. 119, $1.50.

VOLUME 15

73. A further analysis of reasoning in rats. II. The integration of four separate experiences in problem solving. III. The influence of cortical injuries on the process of "direction." By Norman R. F. Maier. Pp. 85, $1.50.
74. The effect of early inanition upon maze learning in the albino rat. By William C. Biel. Pp. 33, $.75.
75. The solution of multiple choice problems by chimpanzees. By Kenneth W. Spence. Pp. 54, $1.00.
76. Color vision and color blindness in monkeys. By Walter F. Grether, Pp. 38, $.75.
77. Delayed reward in discrimination learning by chimpanzees. By Austin H. Riesen. Pp. 54, $1.00.
78. A study of experimentally induced competitive behavior in the white rat. By Charles Nelson Winslow. Pp. 35, $.75.
79. Morphine addiction in chimpanzees. By S. D. S. Spragg. Pp. 132, $1.75.

VOLUME 16

80. Studies of abnormal behavior in the rat. II. A comparison of some convulsion-producing situations. By Norman R. F. Maier and Nathan M. Glaser. Pp. 30, $.75.
81. Negro Crime. By Jess Spirer. Pp. 64, $1.25.
82. Effects of quantitative variation of food-incentive on the performance of physical work by chimpanzees. By Frank Milford Fletcher. Pp. 46, $.75.
83. The relationship between age and the strength of hunger motivation. By S. E. Margolin and M. E. Bunch. Pp. 34, $.75.
84. A field study in Siam of the behavior and social relations of the gibbon (Hylobates lar). By C. R. Carpenter. Pp. 205, $2.00.
85. Companionship preference and dominance in the social interaction of young chimpanzees. By Vincent Nowlis. Pp. 57, $1.25.

COMPARATIVE PSYCHOLOGY MONOGRAPHS

$5.00 per volume. * To be had only on orders for complete sets.

VOLUME 1

1. Studies of the reliability of the problem box and the maze with human and animal subjects. **By William T. Heron an** Walter S. Hunter. Pp. 56, $1.00.
2. A behavioristic study of the activity of the rat. By Curt P. Richter. Pp. 55, $1.00.
3. The distribution of practice in animal learning. By Carl John Warden. Pp. 64, $1.25.
4. Stuttering and allied disorders. By Lewis O. Anderson. Pp. 78, $1.50.
5. The comparative abilities of white and colored children. By Joseph Peterson. Pp. 141, $2.25.

VOLUME 2

6. The relation between "spontaneous" activity and oestrous cycle in the white rat. By G. H. Wang. Pp. 27, $.75.
7. The relative effectiveness of certain incentives in animal learning. By Rietta Simmons. Pp. 79, $1.50.
8. Individual difference in ability versus chance in the learning of the stylus maze. By William T. Heron. Pp. 60, $1.00
9. The suggestibility of normal and mentally defective children. By Irene Case Sherman. Pp. 34, $.75.
10. On the relation of the intelligence to achievement in the case of mentally retarded children. By Maud A. Merrill. Pp 100, $1.50.
11. A comparative study of retention curves for motor habits. By Chiao Tsai. Pp. 29, $.75.
12. The thyroid influence on the behavior of the white rat. By Edna Rickey. Pp. 76, $1.50.

VOLUME 3

13. Oxygen consumption during emotional stimulation. By Edith Totten. Pp. 79, $2.00.
14. Racial influences in the mental and physical development of Mexican children. By Franklin C. Paschal and Louis R Sullivan. Pp. 76, $2.00.

*15. The mental capacity of American-born Japanese children. By Marvin L. Darsie. Pp. 89.

16. Experimental researches upon the sense of hearing in lower vertebrates, including reptiles, amphibians, and fishes. By Ryo Kuroda. Pp. 50, $1.50.
17. A study of the effect of starvation upon behavior by means of the obstruction method. By Frances Holden. Pp. 45 $.75.

VOLUME 4

18. Experiments with form perception and learning in dogs. By Joseph A. Williams. Pp. 70, $1.50.
19. An experimental study of the effects of tobacco smoking on certain psycho-physical functions. By Vivian Ezra Fisher Pp. 50, $1.00.
20. Periodic changes in blood pressure, muscular coördination, and mental efficiency in women. By Helen E. Eagleson Pp. 65, $1.50.
21. Human reactions in a maze of fixed orientation. By Nellie Louise Perkins. Pp. 92, $2.00.

*22. A study of sex behavior in the white rat by means of the obstruction method. By L. H. Warner. Pp. 68.

VOLUME 5

23. Sex development in apes. By Harold C. Bingham. Pp. 166, $2.50.
24. The mind of a gorilla. Part III. Memory. By Robert M. Yerkes. Pp. 92, $1.75.
25. Chimpanzee translocation by means of boxes. By Harold C. Bingham. Pp. 92, $1.75.
26. Selective transportation by chimpanzees. By Harold C. Bingham. Pp. 45, $.75.

VOLUME 6

27. Experimental studies of adaptive behavior in cats. By Donald Keith Adams. Pp. 166, $2.50.
28. A comparative study of certain incentives in the learning of the white rat. By Ernest Mayfield Ligon. Pp. 95, $1.75.
29. Reasoning in white rats. By Norman R. F. Maier. Pp. 93, $1.75.
30. Learning and orientation in ants. By T. C. Schneirla. Pp. 143, $2.00.

VOLUME 7

31. Configurational learning in the goldfish. By F. Theodore Perkins and Raymond Holder Wheeler. Pp. 50, $1.00.
32. Direction orientation in maze running by the white rat. By J. F. Dashiell. Pp. 72, $1.50.
33. Preferential manipulation in children. By Julia Heil Heinlein. Pp. 121, $1.75.
34. The significance of delayed reactions in young children. By Magda Skalet. Pp. 82, $1.50.
35. Whole and part methods in trial and error learning. By Ella May Hanawalt. Pp. 65, $1.25.

VOLUME 8

36. A field study of the chimpanzee. Observations of chimpanzee behavior and environment in Western French Guinea. By Henry W. Nissen. Pp. 122, $1.75.
37. A further study of the delayed reaction in the albino rat. By Walter G. McAllister. Pp. 103, $1.50.
38. Yale laboratories of comparative psychobiology. By Robert M. Yerkes. Pp. 34, $.75.
39. Reward and punishment in animal learning. By Edward L. Thorndike. Pp. 65, $1.25.
40. The reliability of the maze and methods of its determination. By Kenneth W. Spence. Pp. 45, $.75.

VOLUME 9

41. Development of an infant chimpanzee during her first year. By Carlyle F. and Marion M. Jacobsen and Joseph G Yoshioka. Pp. 88, $1.50.

Continued on third cover

BRIGHAM YOUNG UNIVERSITY

3 1197 00704 2408

DATE DUE

CT 1 9 [illegible]
OCT 1 2 REC'D
JUL 2 1 1982
JUL 2 8 [illegible]

DEMCO 38-297